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Attorney's Docket Number:
04585/048002

TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. Application Number:
Not known yet

INTERNATIONAL APPLICATION NUMBER

INTERNATIONAL FILING DATE

PRIORITY DATE CLAIMED

PCT/US98/21349

08 October 1998

14 October 1997

TITLE OF INVENTION:

THERAPEUTIC METHODS COMPRISING USE OF A NEUREGULIN

APPLICANTS FOR DO/EO/US:

Robert N. McBurney, William Holt, David I. Gwynne, and Mark Marchionni

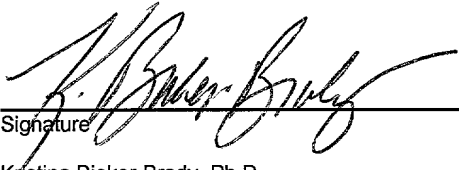
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1.	<input checked="" type="checkbox"/>	This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2.	<input type="checkbox"/>	This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
3.	<input checked="" type="checkbox"/>	This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4.	<input checked="" type="checkbox"/>	A proper Demand for International Preliminary Examination was made by the 19 th month from the earliest claimed priority date.
5.	<input checked="" type="checkbox"/>	A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
a.	<input checked="" type="checkbox"/>	is transmitted herewith (required only if not transmitted by the International Bureau).
b.	<input type="checkbox"/>	has been transmitted by the International Bureau.
c.	<input type="checkbox"/>	Is not required, as the application was filed with the United States Receiving Office (RO/US).
6.	<input type="checkbox"/>	A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7.	<input checked="" type="checkbox"/>	Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
a.	<input type="checkbox"/>	are transmitted herewith (required only if not transmitted by the International Bureau).
b.	<input type="checkbox"/>	have been transmitted by the International Bureau.
c.	<input type="checkbox"/>	have not been made; however, the time limit for making such amendments has NOT expired.
d.	<input checked="" type="checkbox"/>	have not been made and will not be made.
8.	<input type="checkbox"/>	A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9.	<input checked="" type="checkbox"/>	An unsigned oath or declaration of the inventors (35 U.S.C. 371(c)(4)).
10.	<input type="checkbox"/>	A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

11.		An Information Disclosure Statement under 37 CFR 1.97 and 1.98.			
12.		An assignment for recording. A separate cover sheet in compliance with 37 3.28 and 3.31 is included.			
13.	X	A FIRST preliminary amendment.			
		A SECOND or SUBSEQUENT preliminary amendment.			
14.		A substitute specification.			
15.		A change of power of attorney and/or address letter.			
16.		Other items or information:			
17.		<p>The following fees are submitted:</p> <p>BASIC NATIONAL FEE (37 CFR 1.492(A)(1)-(5)):</p> <p>Search Report has been prepared by the EPO or JPO \$ 840.00</p> <p>International preliminary examination fee paid to USPTO (37 CFR 1.482) \$ 670.00</p> <p>No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$ 690.00</p> <p>Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$ 970.00</p> <p>International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) \$ 96.00</p>		\$670.00	
		ENTER APPROPRIATE BASIC FEE AMOUNT =		\$670.00	
		Surcharge of \$130 for furnishing the oath or declaration later than <input type="checkbox"/> 20 OR <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).		\$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	38 - 20 = 8	8	x \$18.00	\$144.00	
Independent claims	4 - 3 =	1	x \$78.00	\$ 78.00	
Multiple dependent claims (if applicable)			+ \$260.00	\$ 260.00	
		TOTAL OF ABOVE CALCULATIONS =		\$1,152.00	
		Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed with this request (Note 37 CFR 1.9, 1.27, 1.28).		\$	
		SUBTOTAL =		\$1,152.00	
		Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 OR <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).		+	\$
		TOTAL NATIONAL FEE =		\$1,152.00	
		Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property.		+	\$
		TOTAL FEES ENCLOSED =		\$1,152.00	
				Amount to be refunded	\$
				charged	\$

a.	X	A check in the amount of \$1,152.00 to cover the above fees is enclosed.
b.		Please charge my Deposit Account No. 03-2095 in the amount of \$ [**, **] to cover the above fees.
c.	X	The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment, to Deposit Account No. 03-2095. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b) must be filed and granted to restore the application to pending status.

<p>SEND ALL CORRESPONDENCE TO:</p> <p>Kristina Bieker-Brady, Ph.D. Clark & Elbing LLP 176 Federal Street Boston, MA 02110-2214</p> <p>Telephone: 617-428-0200 Facsimile: 617-428-7045</p>	 Signature Kristina Bieker-Brady, Ph.D. Reg No. 39,109
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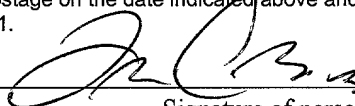
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PATENT

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<u>Luis A. Cruz</u>	
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Robert N. McBurney et al. Art Unit: Not yet Assigned

Serial No.: Not yet Assigned Examiner: Not yet Assigned

Based on PCT/US98/21349

Filed: 08 October 1998

Title: THERAPEUTIC METHODS COMPRISING USE OF A
NEUREGULINAssistant Commissioner of Patents
Washington, D.C. 20231PRELIMINARY AMENDMENT

Prior to examination, Applicants submit the following amendment.

In the claims

Cancel claims 7, 9, 12-21, 24-26, and 28-34. Amend claims 8, 10, 11, 22, 23, 27, 35, and 36 as follows.

8. (Once Amended) [A] The method of [claim 7] claims 1, 2, 3, or 4, wherein the neuregulin or fragment or derivative thereof comprises an amino acid sequence of the following formula:

WYBAZCX

wherein WYBAZCX is composed of amino acid sequences that include one or more sequences shown in FIGS. 1 through 15 (which includes SEQ ID NOS:2, 4, 5, 8, 9, 12, 14, 15, 18, 19, 22, 23, 26, 27, 30, 33, 35, 38, 39, 41, 44, 45 and 48), wherein W comprises the polypeptide segment F, or is absent; wherein Y comprises the polypeptide segment E, or is absent; wherein Z comprises the polypeptide segment G or is absent; and wherein X comprise a polypeptide segment selected from the group consisting of C/D HKL, C/D H, C/D HL, C/D D, C/D' HL, C/D' HKL, C/D' H, C/D' D, C/D C/D' HKL, C/D C/D' H, C/D C/D' HL, C/D C/D' D, C/d D'H, C/D D' HL, C/D D' HKL, C/D' D' H, C/D' D' HL, C/D' D' HKL, C/D C/D' D' H, C/D C/D' D' HL and C/D C/D' D' HKL, and preferably that either

- a) at least one of F, Y, B, A, Z, C or X is of bovine origin; or
- b) Y comprises the polypeptide segment E; or
- c) X comprises the polypeptide segments C/D HKL, C/D D, C/D' HKL, C/D C/D' HKL, C/D C/D' D, C/D D' H, C/D D' HL, C/D D' HKL, C/D' D' H, C/D' D' HKL, C/D C/D' D'H, C/D C/D' D HL, C/D C/D' D' HKL, C/D'H, C/D C/D' H or C/D C/D' HL.

10. (Once Amended) The method of [claim 7] claims 1, 2, 3, or 4, wherein the neuregulin or fragment or derivative thereof comprises FBA polypeptide segments, FEBA polypeptides segments, EBA polypeptide segments, EBA' polypeptide segments or FEBA' polypeptide segments.

11. (Once Amended) The method of [claim 7] claims 1, 2, 3, or 4, wherein the

neuregulin is encoded by a nucleic acid that [comprises one of] is selected from the group consisting of SEQ ID NOS: 49, 51 and 53.

22. (Once Amended) The method of [claim 7] claims 1, 2, 3, or 4, wherein the neuregulin or fragment or derivative comprises a sequence that is shown in Figures 7, 8 or 9.

23. (Once Amended) [A] The method of any one of claims [1-6] 1-4, wherein a nucleic acid encoding a neuregulin or a fragment or derivative thereof is administered to the mammal.

27. (Once Amended) The method of [claim 25] claims 1, 2, 3, or 4, wherein the neuregulin or neuregulin fragment or derivative comprises FBA polypeptide segments, FEBA polypeptides segments, EBA polypeptide segments, EBA' polypeptide segments or FEBA' polypeptide segments.

35. (Once Amended) [A] The method of any one of claims [1-34] 1-4, wherein the administered neuregulin or fragment or derivative[, or the administered nucleic acid encodes a neuregulin fragment or derivative] exhibits at least about a 10% reduction in infarct volume in an *in vivo* cerebral ischemia assay.

36. (Once Amended) [A] The method of any one of claims [1-34] 1-4, wherein the mammal is a human.

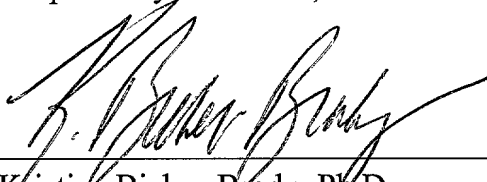
REMARKS

No new matter has been introduced by the above amendments. If there are any charges, or any credits, please apply them to Deposit Account No. 03-2095.

Respectfully submitted,

Date:

May 5, 2000



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THERAPEUTIC METHODS COMPRISING USE OF A NEUREGULIN

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to methods for treatment of certain neurological-related injuries and disorders comprising use of a neuregulin, or a fragment or derivative of a neuregulin, or a nucleic acid encoding a neuregulin or neuregulin fragment or derivative.

2. Background

Nerve cell death (degeneration) can cause potentially devastating and irreversible effects for an individual and may occur e.g. as a result of stroke, heart attack or other brain or spinal chord ischemia or trauma. Additionally, neurodegenerative disorders involve nerve cell death (degeneration) such as Alzheimer's disease, Parkinson's disease, Huntington's disease, Amyotrophic Lateral Sclerosis, Down's Syndrome and Korsakoff's disease.

Therapies have been investigated to treat nerve cell degeneration and related disorders, e.g., by limiting the extent of nerve cell death that may otherwise occur to an individual as well as promoting repair, remodeling and reprogramming after stroke or other neuronal injury. See, e.g., F. Seil, *Curr Opin Neuro*, 10:49-51 (1997); N. L. Reddy et al., *J Med Chem*, 37:260-267 (1994); and WO 95/20950.

Certain growth factors have been reported to exhibit neuroprotective properties. In particular, nerve growth factor (NGF) has been evaluated in certain neuroprotective models. See, for example, G. Sinson et al., *J Neurosurg*, 86(3):511-518 (1997); and G. Sinson et al., *J Neurochem*, 65(5):2209-2216 (1995). Osteogenic protein-1 (OP-1) has been evaluated in a rat model of cerebral hypoxia/ischemia for neuroprotective activity. G. Perides, *Neurosci Lett*, 187(1):21-24 (1995). Glial cell line-derived neurotrophic factor (GDNF) was reported to exhibit trophic activity on certain populations of central neurons. Y. Wang et al., *J Neurosci*, 17(11):4341-4348 (1997). Small molecules also have been investigated as neuroprotective agents, such

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as MK-801. See B. Meldrum, *Cereb Brain Metab Rev*, 2:27-57 (1990); D. Choi, *Cereb Brain Metab Rev*, 2:27-57 (1990).

However, no effective pharmacotherapies are in regular clinical use for ischemia-induced brain injury or other such injuries and disorders. See, for example, 5 Y. Wang et al., *supra*; G. Sinson et al., *J Neurochem*, *J Neurochem*, 65(5):2209 (1995).

It thus would be highly desirable to have new neuroprotective agents, particularly agents to limit the extent or otherwise treat nerve cell death (degeneration) that occur with stroke, heart attack or brain or spinal cord trauma, or to treat 10 Alzheimer's disease, Parkinson's disease, Huntington's disease, Amyotrophic Lateral Sclerosis, Down's Syndrome and Korsakoff's disease. It also would be desirable to have agents that promote repair, remodeling or reprogramming after stroke or other neuronal injury.

SUMMARY OF THE INVENTION

15 The present invention provides methods for treatment and/or prophylaxis of certain neurological-related disorders, particularly treatment or prophylaxis of the effects of stroke, brain or spinal cord injury or ischemia, heart attack, optic nerve and retinal injury and ischemia and other acute-type conditions disclosed herein as well as chronic-type conditions, specifically epilepsy, Alzheimer's disease, Parkinson's 20 disease, Huntington's disease, Amyotrophic Lateral Sclerosis, Down's Syndrome, Korsakoff's disease, cerebral palsy and/or age-dependent dementia. Methods of the invention also include therapies for promoting repair, remodeling or reprogramming after stroke or other neuronal injury.

The methods of the invention comprise administration of an effective amount 25 of neuregulin, or fragment or derivative of a neuregulin, or a nucleic acid encoding a neuregulin or a neuregulin fragment or derivative (i.e. gene therapy), to a patient suffering from or susceptible to such conditions.

Neuregulins are members of the epidermal growth factor (EGF) superfamily and include glial growth factor (GGF), acetylcholine receptor-inducing activity 30 (ARIA), neu differentiation factor (NDF) and heregulins (HRF). See D. E. Wen et al., *Cell*, 69:559-572 (1992); W.E. Holmes et al., *Science*, 256:1205-1210 (1992); M.A. Marchionni et al., *Nature*, 362:312-318 (1993); and D.L. Falls, *Cell*, 72:801-815

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(1993). A variety of neuregulins and fragments and derivatives thereof can be employed in the methods of the invention. For example, suitable agents have been disclosed in U.S. Patent 5,530,109 and PCT/US93/07491. Neuregulins also have been reported in U.S. Patent 5,367,060. Preferred neuregulins include regions shown

5 in FIGS. 1-2 (SEQ ID NOS. 2 and 4), also known as the E sequence. Preferred neuregulins or fragments or derivatives also include those that contain the C, C/D or C/D' sequences as shown in Figures 7, 8 and 9 respectively of the drawings, or those neuregulins or fragments or derivatives that have substantial homology to the peptide sequences shown in Figures 7, 8 or 9, e.g. at least about 70 percent homology, or at

10 least about 80 percent homology, or more preferably at least about 90 or 95 percent homology to the peptide sequences shown in Figures 7, 8 or 9. Preferred nucleic acids and fragments and derivatives for use in the methods of the invention include those nucleic acids that include one or more nucleic acids sequences shown in Figures 7, 8 and 9 of the drawings, or those nucleic acids that that have substantial homology

15 to the nucleic acid sequences shown in Figures 7, 8 or 9, e.g. at least about 70, 80, 90 or 95 percent homology to the nucleic acid sequences shown in Figures 7, 8 or 9. A particularly preferred neuregulin is encoded by DNA obtainable from the clone pGGF2HBS11 (ATCC Deposit No. 75347). Also preferred are neuregulins encoded by DNA obtainable from GGF2BPP5, GGF2BPP2 and GGF2BPP4.

20 Typical patients that may be treated in accordance with the methods of the invention are persons suffering from brain or spinal cord trauma or ischemia, stroke, heart attack, hypoxia, hypoglycemia, post-surgical neurological deficits, decreased blood flow or nutrient supply to retinal tissue or optic nerve, retinal trauma or ischemia or optic nerve injury. Patients suffering from chronic-type conditions also

25 may be treated in accordance with the invention, specifically subjects suffering from or susceptible to epilepsy, Parkinson's disease, Huntington's disease, Amyotrophic Lateral Sclerosis, Alzheimer's disease, Down's Syndrome, Korsakoff's disease, cerebral palsy and/or age-dependent dementia.

Also, as discussed above, a neuregulin or fragment or derivative thereof or

30 nucleic acid encoding same, may be administered to promote repair, remodeling or reprogramming to a subject that has suffered stroke or other neuronal injury such as traumatic brain or spinal cord injury. In such cases, the therapeutic agent may be

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suitably administered to the subject over an extended period following the injury, e.g. at least about 1, 2, 3, 4, 6, 8, 12 or 16 weeks following the injury.

Other aspects of the invention are disclosed *infra*.

BRIEF DESCRIPTION OF THE DRAWINGS

5 FIG. 1 shows a nucleotide sequence (SEQ ID NO:1) encoding a preferred neuregulin region (E segment of human GGF) and the amino acid sequence (SEQ ID NO:2) of that preferred region.

FIG. 2 shows a nucleotide sequence (SEQ ID NO:3) encoding a preferred neuregulin region (E segment of bovine GGF) and the amino acid sequence (SEQ ID
10 NO:4) of that preferred region.

FIG. 3 shows nucleotide sequences (SEQ ID NOS:6-7) encoding further neuregulin regions (B segment of human and bovine GGF) and amino acid sequences (SEQ ID NOS:5 and 8) of those regions. Line 1 is the predicted amino acid sequence of bovine B segment, line 2 is a nucleotide sequence of bovine B segment, line 3 is a
15 nucleotide sequence of human B segment (nucleotide base matches are indicated with a vertical line), and line 4 is the predicted amino acid sequence of human B segment shown where it differs from the bovine sequence set forth in line 1 of the figure.

FIG. 4 shows nucleotide sequences (SEQ ID NOS:10-11) encoding further neuregulin regions (A segment of human and bovine GGF) and amino acid sequences
20 (SEQ ID NOS:9 and 12) of those regions. Line 1 is the predicted amino acid sequence of bovine A segment, line 2 is a nucleotide sequence of bovine A segment, line 3 is a nucleotide sequence of human A segment (nucleotide base matches are indicated with a vertical line), and line 4 is the predicted amino acid sequence of human A segment shown where it differs from the bovine sequence set forth in line 1
25 of the figure.

FIG. 5 shows a nucleotide sequence (SEQ ID NO:13) encoding a further neuregulin region (A' segment of bovine GGF) and the predicted amino acid sequence (SEQ ID NO:14) of that region.

FIG. 6 shows nucleotide sequences (SEQ ID NOS:16-17) encoding further
30 neuregulin regions (G segment of bovine and human GGF) and amino acid sequences (SEQ ID NOS:15 and 18) of that region. Line 1 is the predicted amino acid sequence of bovine G segment, line 2 is a nucleotide sequence of bovine G segment, line 3 is a

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nucleotide sequence of human G segment (nucleotide base matches are indicated with a vertical line), and line 4 is the predicted amino acid sequence of human G segment shown where it differs from the bovine sequence set forth in line 1 of the figure.

FIG. 7 shows nucleotide sequences (SEQ ID NOS:20-21) encoding further
 5 neuregulin regions (C segment of bovine and human GGF) and amino acid sequences (SEQ ID NOS:19 and 22) of those regions. Line 1 is the predicted amino acid sequence of bovine C segment, line 2 is a nucleotide sequence of bovine C segment, line 3 is a nucleotide sequence of human C segment (nucleotide base matches are indicated with a vertical line), and line 4 is the predicted amino acid sequence of
 10 human C segment shown where it differs from the bovine sequence set forth in line 1 of the figure.

FIG. 8 shows nucleotide sequences (SEQ ID NOS:24-25) encoding further
 neuregulin regions (C/D segment of human and bovine GGF) and amino acid
 sequences (SEQ ID NOS:23 and 26) of those regions. Line 1 is the predicted amino
 15 acid sequence of bovine C/D segment, line 2 is a nucleotide sequence of bovine C/D segment, line 3 is a nucleotide sequence of human C/D segment (nucleotide base matches are indicated with a vertical line), and line 4 is the predicted amino acid sequence of human C/D segment shown where it differs from the bovine sequence set forth in line 1 of the figure.

FIG. 9 shows nucleotide sequences (SEQ ID NOS:28-29) encoding a further
 neuregulin region (C/D' segment of the human and bovine GGF) and the amino acid
 sequence (SEQ ID NO:27) of that region. Line 1 is the predicted amino acid sequence
 of the C/D' segment, line 2 is a nucleotide sequence of bovine C/D' segment and line
 3 is a nucleotide sequence of human C/D' segment (nucleotide base matches are
 25 indicated with a vertical line).

FIG. 10 shows nucleotide sequences (SEQ ID NOS:31-32) encoding a further
 neuregulin region (D segment of the human and bovine GGF) and the amino acid
 sequence (SEQ ID NO:30) of that region. Line 1 is the predicted amino acid sequence
 of the D segment, line 2 is a nucleotide sequence of bovine D segment and line 3 is a
 30 nucleotide sequence of human D segment (nucleotide base matches are indicated with a vertical line).

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FIG. 11 shows nucleotide sequence (SEQ ID NO:34) encoding a further neuregulin region (D' segment of bovine GGF) and the amino acid sequence (SEQ ID NO:33) of that region.

FIGS. 12A-12B show nucleotide sequences (SEQ ID NOS:36-37) encoding further neuregulin regions (H segment of human and bovine GGF) and amino acid sequences (SEQ ID NO:35 and 38) of that region. Line 1 is the predicted amino acid sequence of bovine H segment, line 2 is a nucleotide sequence of bovine H segment, line 3 is a nucleotide sequence of human H segment (nucleotide base matches are indicated with a vertical line), and line 4 is the predicted amino acid sequence of human H segment shown where it differs from the bovine sequence set forth in line 1 of the figure.

FIG. 13 shows a nucleotide sequence (SEQ ID NO:40) encoding a further neuregulin region (K segment of bovine GGF) and the amino acid sequence (SEQ ID NO:39) of that region.

FIGS. 14A-14C show nucleotide sequences (SEQ ID NOS:42-43) encoding a further neuregulin region (L segment of bovine and human GGF) and amino acid sequences (SEQ ID NO:41 and 44) of that region. Line 1 is the predicted amino acid sequence of bovine L segment, line 2 is a nucleotide sequence of bovine L segment, line 3 is a nucleotide sequence of human L segment (nucleotide base matches are indicated with a vertical line), and line 4 is the predicted amino acid sequence of human L segment shown where it differs from the bovine sequence set forth in line 1 of the figure.

FIG. 15 shows nucleotide sequences (SEQ ID NOS:46-47) encoding further neuregulin regions (F segment of bovine and human GGF) and amino acid sequences (SEQ ID NOS:45 and 48) of that region. Line 1 is the predicted amino acid sequence of bovine F segment, line 2 is a nucleotide sequence of bovine F segment, line 3 is a nucleotide sequence of human F segment (nucleotide base matches are indicated with a vertical line), and line 4 is the predicted amino acid sequence of human F segment shown where it differs from the bovine sequence set forth in line 1 of the figure.

FIGS. 16A-16C show the nucleotide sequence (SEQ ID NO:49) and deduced amino acid sequence (SEQ ID NO:50) of GGF2BPP4.

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FIGS. 17A-17B show the nucleotide sequence (SEQ ID NO:51) and deduced amino acid sequence (SEQ ID NO:52) of GGF2BPP2.

FIGS. 18A-18B show the nucleotide sequence (SEQ ID NO:53) and deduced amino acid sequence (SEQ ID NO:54) of GGF2BPP5.

5 DETAILED DESCRIPTION OF THE INVENTION

As discussed above, preferred neuregulins for use in the therapeutic methods of the present invention include those disclosed in U.S. Patent 5,530,109 and PCT/US93/07491, incorporated herein by reference. Particularly preferred neuregulins comprise an amino acid sequence of the following formula:

10 WYBAZCX

wherein WYBAZCX is composed of amino acid sequences that include one or more sequences shown in FIGS. 1 through 15 (which includes SEQ ID NOS:2, 4, 5, 8, 9, 12, 14, 15, 18, 19, 22, 23, 26, 27, 30, 33, 35, 38, 39, 41, 44, 45 and 48), wherein W comprises the polypeptide segment F, or is absent; wherein Y comprises the

15 polypeptide segment E, or is absent; wherein Z comprises the polypeptide segment G or is absent; and wherein X comprise a polypeptide segment selected from the group consisting of C/D HKL, C/D H, C/D HL, C/D D, C/D' HL, C/D' HKL, C/D' H, C/D' D, C/D C/D' HKL, C/D C/D' H, C/D C/D' HL, C/D C/D' D, C/d D'H, C/D D' HL, C/D D' HKL, C/D' D' H, C/D' D' HL, C/D' D' HKL, C/D C/D' D' H, C/D C/D' D' HL and C/D C/D' D' HKL, and preferably that either

- a) at least one of F, Y, B, A, Z, C or X is of bovine origin; or
 - b) Y comprises the polypeptide segment E; or
 - c) X comprises the polypeptide segments C/D HKL, C/D D, C/D' HKL, C/D C/D' HKL, C/D C/D' D, C/D D' H, C/D D' HL, C/D D' HKL, C/D' D' H, C/D' D' HKL, C/D C/D' D'H, C/D C/D' D HL, C/D C/D' D' HKL, C/D'H, C/D C/D' H or C/D C/D' HL.
- 25

Particularly preferred neuregulins also include those polypeptides that include the segments FB polypeptides that include the segments FBA' (i.e. the groups F, B and A' as defined herein including in the drawings); polypeptides that include the segments EBA (i.e. the groups E, B and A as defined herein including in the drawings); polypeptides that include the segments EBA' (i.e. the groups E, B and A' as defined herein including in the drawings); A (i.e. the group A as defined herein

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including in the drawings); polypeptides that include the segments FEBA (i.e. the groups F, E, B and A as defined herein including in the drawings); polypeptides that include the segments FBA' (i.e. the groups F, B and A' as defined herein including in the drawings); and polypeptides that include the segments FEBA' (i.e. the groups F, E, B and A' as defined herein including in the drawings).

Also preferred are nucleic acids that code for the above preferred polypeptides.

A "fragment" or "derivative" of a neuregulin refers to herein 1) a peptide in which one or more amino acid residues are with a conserved or non-conserved amino acid residue (preferably a conserved amino acid residue) and such substituted amino acid residue may or may not be one encoded by the genetic code, or (ii) a peptide in which one or more of the amino acid residues includes a substituent group, or (iii) a peptide in which the mature protein is fused with another compound, such as a compound to increase the half-life of the polypeptide (for example, polyethylene glycol). Thus, a fragment or derivative for use in accordance with the methods of the invention includes a proprotein, which can be activated by cleavage of the proprotein portion to produce an active mature polypeptide.

The polypeptide fragments and derivatives of the invention are of a sufficient length to uniquely identify a region of a neuregulin. Neuregulin fragments thus preferably comprise at least 8 amino acids, usually at least about 12 amino acids, more usually at least about 15 amino acids, still more typically at least about 30 amino acids, even more typically at least about 50 or 70 amino acids. Preferred fragments or derivatives for use in the methods of the invention include those that have at least about 70 percent homology (sequence identity) to any of the preferred sequences mentioned above, more preferably about 80 percent or more homology to any of the preferred sequences mentioned above, still more preferably about 85 to 90 percent or more homology to any of the preferred sequences mentioned above. Sequence identity or homology with respect to a neuregulin as referred to herein is the percentage of amino acid sequences of a neuregulin protein or fragment or derivative thereof that are identical with a specified sequence, after introducing any gaps necessary to achieve the maximum percent homology.

The neuregulin fragments and derivatives for use in the methods of the invention preferably exhibit good activity in standard neuroprotective assays such as

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the *in vivo* cerebral ischemia assay of Example 1, which follows. That assay includes the following steps: a) continuous intraventricular infusion of the protein fragment or derivative or vehicle alone to test rats for three days prior to inducing focal ischemic infarcts in right lateral cerebral cortex; and b) twenty-four hours after inducing

5 ischemic infarcts, infarct volume in each test animal is determined by image analysis. Preferably, a protein fragment or derivative of the invention provides at least about a 10% reduction in infarct volume relative to vehicle-treated animals, more preferably about a 20% reduction in infarct volume, still more preferably about a 25% reduction in infarct volume relative to vehicle-treated animals in such an assay. References

10 herein to *in vivo* cerebral ischemia assay are intended to refer to an assay of the above steps a) and b), which are more fully described in Example 1 which follows.

As discussed above, neuregulin nucleic acid fragments and derivatives are also provided for use in the methods of the invention. Those fragments and derivatives typically are of a length sufficient to bind to a sequence of any of the nucleic acid

15 sequences shown in Figures 1-15 of the drawings, including SEQ ID NOS:1, 3, 6, 7, 10, 11, 13, 16, 17, 20, 21, 24, 25, 28, 29, 31, 32, 34, 36, 37, 40, 42 and 43 under the following moderately stringent conditions (referred to herein as "normal stringency" conditions): use of a hybridization buffer comprising 20% formamide in 0.8M saline/0.08M sodium citrate (SSC) buffer at a temperature of 37°C and remaining

20 bound when subject to washing once with that SSC buffer at 37°C.

Preferred neuregulin nucleic acid fragments and derivatives of the invention will bind to a sequence of any of the nucleic acid sequences shown in Figures 1-15 of the drawings, including SEQ ID NOS:1, 3, 6, 7, 10, 11, 13, 16, 17, 20, 21, 24, 25, 28, 29, 31, 32, 34, 36, 37, 40, 42 and 43 under the following highly stringent conditions

25 (referred to herein as "high stringency" conditions): use of a hybridization buffer comprising 20% formamide in 0.9M saline/0.09M sodium citrate (SSC) buffer at a temperature of 42°C and remaining bound when subject to washing twice with that SSC buffer at 42°C.

The neuregulin nucleic acid fragments and derivatives preferably should

30 comprise at least 20 base pairs, more preferably at least about 50 base pairs, and still more preferably a nucleic acid fragment or derivative of the invention comprises at least about 100, 200, 300 or 400 base pairs. In some preferred embodiments, the

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nucleic acid fragment or derivative is bound to some moiety which permits ready identification such as a radionucleotide, fluorescent or other chemical identifier.

Isolated neuregulin and peptide fragments or derivatives of the invention are preferably produced by recombinant methods, although suitable neuregulins also can be isolated from various sources. See the procedures disclosed U.S. Patent 5,530,109; U.S. Patent 5,367,060; and PCT/US93/07491, incorporated herein by reference. A wide variety of molecular and biochemical methods are available for generating and expressing neuregulin; see e.g. the procedures disclosed in *Molecular Cloning, A Laboratory Manual* (2nd Ed., Sambrook, Fritsch and Maniatis, Cold Spring Harbor), *Current Protocols in Molecular Biology* (Eds. Ausubel, Brent, Kingston, More, Feidman, Smith and Stuhl, Greene Publ. Assoc., Wiley-Interscience, NY, N.Y. 1992) or other procedures that are otherwise known in the art. For example, neuregulin or fragments or derivatives thereof may be obtained by chemical synthesis, or more preferably by expression in bacteria such as *E coli* and eukaryotes such as yeast, baculovirus, or mammalian cell-based expression systems, etc., depending on the size, nature and quantity of neuregulin or fragment or derivative thereof. More particularly, a recombinant DNA molecule comprising a vector and a DNA segment encoding neuregulin, or a fragment or derivative thereof, can be constructed. Suitable vectors include e.g. baculovirus-derived vectors for expression in insect cells (see Pennock et al., *Mol. Cell. Biol.*, 4:399-406 (1984)), T7-based expression vector for expression in bacteria (see Rosenberg et al., *Gene*, 56:125-135 (1987)) and the pMSXND expression vector for expression in mammalian cells (Lee and Nathans, *J. Biol. Chem.*, 263:3521-3527 (1988)). The DNA segment can be present in the vector operably linked to regulatory elements, e.g., a promoter (e.g., polyhedron, T7 or metallothionein (Mt-I) promoters), or a leader sequence to provide for secretory expression of the polypeptide. The recombinant DNA molecule containing the DNA coding for a neuregulin or a fragment or derivative thereof can be introduced into appropriate host cells by known methods. Suitable host cells include e.g. prokaryotes such as *E. coli*, *Bacillus subtilis*, etc., and eukaryote such as animal cells and yeast strains, e.g., *S. cerevisiae*. Mammalian cells may be preferred such as J558, NSO, SP2-O or CHO. In general, conventional culturing conditions can be employed. See Sambrook, *supra*. Stable transformed or transfected cell lines can then be selected.

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The expressed neuregulin or fragment or derivative thereof then can be isolated and purified by known methods. Typically the culture medium is centrifuged and the supernatant purified by affinity or immunoaffinity chromatography, e.g. Protein-A or Protein-G affinity chromatography or an immunoaffinity protocol comprising use of
5 monoclonal antibodies that bind neuregulins.

Neuregulin nucleic acids used in the methods of the invention are typically isolated, meaning the nucleic acids comprise a sequence joined to a nucleotide other than that which it is joined to on a natural chromosome and usually constitute at least about 0.5%, preferably at least about 2%, and more preferably at least about 5% by
10 weight of total nucleic acid present in a given fraction. A partially pure nucleic acid constitutes at least about 10%, preferably at least about 30%, and more preferably at least about 60% by weight of total nucleic acid present in a given fraction. A pure nucleic acid constitutes at least about 80%, preferably at least about 90%, and more preferably at least about 95% by weight of total nucleic acid present in a given
15 fraction.

As discussed above, the present invention includes methods for treating and preventing certain neurological-related injuries and disorders, comprising the administration of an effective amount of a neuregulin or fragment or derivative thereof, or nucleic acid encoding same, to a subject including a mammal, particularly
20 a human, in need of such treatment.

In particular, the invention provides methods for treatment and/or prophylaxis of nerve cell death (degeneration) resulting from hypoxia, hypoglycemia, brain or spinal cord ischemia, brain or spinal cord trauma, stroke, heart attack or drowning. Typical candidates for treatment include e.g. heart attack, stroke and/or persons
25 suffering from cardiac arrest neurological deficits, brain or spinal cord injury patients, patients undergoing major surgery such as heart surgery where brain ischemia is a potential complication and patients such as divers suffering from decompression sickness due to gas emboli in the blood stream. Candidates for treatment also will include those patients undergoing a surgical procedure involving extra-corporal
30 circulation such as e.g. a bypass procedure.

The invention also provides methods for treatment which comprise administration of a neuregulin or fragment or derivative thereof, or nucleic acid

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encoding same, to a patient that is undergoing surgery or other procedure where brain or spinal cord ischemia is a potential risk. For example, carotid endarterectomy is a surgical procedure employed to correct atherosclerosis of the carotid arteries. Major risks associated with the procedure include intraoperative embolization and the danger of hypertension in the brain following increased cerebral blood flow, which may result in aneurysm or hemorrhage. Thus, an effective amount of a neuregulin or fragment or derivative thereof, or nucleic acid encoding same, could be administered pre-operatively or peri-operatively to reduce such risks associated with carotid endarterectomy, or other post-surgical neurological deficits.

10 The invention also is effective to promote and enhance recovery from acute nerve cell death and neurological conditions. Thus, for example, a neuregulin or fragment or derivative thereof, or nucleic acid encoding same, could be administered to promote repair, remodeling or reprogramming to a patient that has suffered from stroke or other neuronal injury, suitably for an extended period as discussed above. A therapeutic agent of the invention also could be administered post-operatively to promote recovery from any neurological deficits that may have occurred to a patient that has undergone surgery.

15 The invention further includes methods for prophylaxis against neurological deficits resulting from e.g. coronary artery bypass graft surgery and aortic valve replacement surgery, or other procedure involving extra-corporal circulation. Those methods will comprise administering to a patient undergoing such surgical procedures an effective amount of a neuregulin or fragment or derivative thereof, or nucleic acid encoding same, typically either pre-operatively or peri-operatively.

20 The invention also provides methods for prophylaxis and treatment against neurological injury for patients undergoing myocardial infarction, a procedure that can result in ischemic insult to the patient. Such methods will comprise administering to a patient undergoing such surgical procedure an effective amount of a neuregulin or fragment or derivative thereof, or nucleic acid encoding same, typically either pre-operatively or peri-operatively.

25 Also provided are methods for treating or preventing neuropathic pain such as may be experienced by cancer patients, persons having diabetes, amputees and other persons who may experience neuropathic pain. These methods for treatment comprise

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administration of an effective amount of a neuregulin or fragment or derivative thereof, or nucleic acid encoding same, to a patient in need of such treatment.

The invention also provides methods for treatment and prophylaxis against retinal ischemia or degeneration and resulting visual loss. For example, a neuregulin or fragment or derivative thereof, can be administered parenterally or by other
5 procedure as described herein to a subject a suffering from or susceptible to ischemic insult that may adversely affect retinal function, e.g., significantly elevated intraocular pressures, diseases such as retinal artery or vein occlusion, diabetes or other ischemic ocular-related diseases. Post-ischemic administration also may limit retinal damage.

10 The invention also includes methods for treating and prophylaxis against decreased blood flow or nutrient supply to retinal tissue or optic nerve, or treatment or prophylaxis against retinal trauma or optic nerve injury. Subjects for treatment according to such therapeutic methods of the invention may be suffering or susceptible to retinal ischemia that is associated with atherosclerosis, venous capillary
15 insufficiency, obstructive arterial or venous retinopathies, senile macular degeneration, cystoid macular edema or glaucoma, or the retinal ischemia may be associated with a tumor or injury to the mammal. Intravitreal injection also may be a preferred administration route to provide more direct treatment to the ischemic retina.

The invention further provides a method of treating Korsakoff's disease, a
20 chronic alcoholism-induced condition, comprising administering to a subject including a mammal, particularly a human, an effective amount of a neuregulin or fragment or derivative thereof, in an amount effective to treat the disease.

Compounds of the invention are anticipated to have utility for the attenuation of cell loss, hemorrhages and/or amino acid changes associated with Korsakoff's disease.

25 The invention further includes methods for treating a person suffering from or susceptible to epilepsy, emesis, narcotic withdrawal symptoms and age-dependent dementia, comprising administering to a subject including a mammal, particularly a human, an effective amount of a neuregulin or fragment or derivative thereof, in an amount effective to treat the condition.

30 It will be appreciated that in some instances a neuregulin or a fragment or derivative thereof will be preferably administered to a subject rather than a neuregulin nucleic acid, particularly where a patient is suffering from or susceptible to an acute

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neurological injury that demands immediate therapy. For example, administration of a neuregulin polypeptide may be preferred to a patient suffering from stroke, heart attack, traumatic brain injury and the like where it is desired to deliver the active therapeutic as quickly as possible.

5 In the therapeutic methods of the invention, neuregulin peptides and nucleic acids may be suitably administered to a subject such as a mammal, particularly a human, by any of a number of routes including parenteral (including subcutaneous, intramuscular, intravenous and intradermal), oral, rectal, nasal, vaginal and optical (including buccal and sublingual) administration. A neuregulin protein or nucleic acid
10 or fragment or derivative thereof may be administered to a subject alone or as part of a pharmaceutical composition, comprising the peptide or nucleic acid together with one or more acceptable carriers and optionally other therapeutic ingredients. The carriers should be "acceptable" in the sense of being compatible with the other ingredients of the formulation and not deleterious to the recipient thereof.

15 Nucleic acids encoding a neuregulin or a neuregulin fragment or derivative can be administered to a patient by generally known gene therapy procedures. See, for example, WO 90/11092 and WO 93/00051. Thus, for instance, the nucleic acids may be introduced into target cells by any method which will result in the uptake and expression of the nucleic acid by the target cells. These methods can include vectors,
20 liposomes, naked DNA, adjuvant-assisted DNA, catheters, etc. Preferably, the administered nucleic acid codes for an appropriate secretory sequence to promote expression upon administration. Suitable vectors for administering a nucleic acid in accordance with the invention include chemical conjugates such as described in WO 93/04701, which has targeting moiety (e.g. a ligand to a cellular surface receptor), and
25 a nucleic acid binding moiety (e.g. polylysine), viral vector (e.g. a DNA or RNA viral vector), fusion proteins such as described in PCT/US 95/02140 (WO 95/22618) which is a fusion protein containing a target moiety (e.g. an antibody specific for a target cell) and a nucleic acid binding moiety (e.g. a protamine), plasmids, phage, etc. The vectors can be chromosomal, non-chromosomal or synthetic.

30 Preferred vectors include viral vectors, fusion proteins and chemical conjugates. Retroviral vectors include moloney murine leukemia viruses. DNA viral vectors are preferred. These vectors include pox vectors such as orthopox or avipox

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vectors, herpes virus vectors such as a herpes simplex I virus (HSV) vector [A.I. Geller et al., *J. Neurochem*, 64:487 (1995); F. Lim et al., in *DNA Cloning: Mammalian Systems*, D. Glover, Ed. (Oxford Univ. Press, Oxford England) (1995); A.I. Geller et al., *Proc Natl. Acad. Sci. U.S.A.*:90 7603 (1993); A.I. Geller et al., *Proc Natl. Acad. Sci USA*, 87:1149 (1990)], Adenovirus Vectors [LeGal LaSalle et al., *Science*, 259:988 (1993); Davidson, et al., *Nat. Genet.*, 3:219 (1993); Yang et al., *J. Virol.*, 69:2004 (1995)] and Adeno-associated Virus Vectors [Kaplitt, M.G., et al., *Nat. Genet.*, 8:148 (1994)].

Pox viral vectors introduce the gene into the cell cytoplasm. Avipox virus vectors result in only a short-term expression of the nucleic acid. Adenovirus vectors, adeno-associated virus vectors and herpes simplex virus (HSV) vectors are preferred for introducing the nucleic acid into neural cells. The adenovirus vector results in a shorter term expression (about 2 months) than adeno-associated virus (about 4 months), which in turn is shorter than HSV vectors. The particular vector chosen will depend upon the target cell and the specific condition being treated. The introduction can be by standard techniques, e.g. infection, transfection, transduction or transformation. Examples of modes of gene transfer include e.g., naked DNA, $\text{Ca}_3(\text{PO}_4)_2$ precipitation, DEAE dextran, electroporation, protoplast fusion, lipofecton, cell microinjection, and viral vectors.

A vector can be employed to target essentially any desired target cell. For example, stereotaxic injection can be used to direct the vectors (e.g. adenovirus, HSV) to a desired location. Additionally, the particles can be delivered by intracerebroventricular (icv) infusion using a minipump infusion system, such as a SynchroMed Infusion System. A method based on bulk flow, termed convection, has also proven effective at delivering large molecules to extended areas of the brain and may be useful in delivering the vector to the target cell (Bobo et al., *Proc. Natl. Acad. Sci. USA*, 91:2076-2080 (1994); Morrison et al., *Am. J. Physiol.*, 266:292-305 (1994)). Other methods that can be used include catheters, intravenous, parenteral, intraperitoneal and subcutaneous injection, and oral or other known routes of administration.

Parenteral formulations for administration of a neuregulin or a fragment or derivative thereof may be in the form of liquid solutions or suspensions; for oral

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administration, formulations may be in the form of tablets or capsules; and for intranasal formulations, in the form of powders, nasal drops, or aerosols.

Methods well known in the art for making formulations are found in, for example, "Remington's Pharmaceutical Sciences". Formulations for parenteral administration may, for example, contain as excipients sterile water or saline, polyalkylene glycols such as polyethylene glycol, oils of vegetable origin, or hydrogenated naphthalenes, biocompatible, biodegradable lactide polymer, or polyoxyethylene-polyoxypropylene copolymers may be used to control the release of the present factors. Other potentially useful parenteral delivery systems for a neuregulin or fragments or derivatives thereof include ethylene-vinyl acetate copolymer particles, osmotic pumps, implantable infusion systems, and liposomes. Formulations for inhalation may contain as excipients, for example, lactose, or may be aqueous solutions containing, for example, polyoxyethylene-9-lauryl ether, glycocholate and deoxycholate, or may be oily solutions for administration in the form of nasal drops, or as a gel to be applied intranasally. Formulations for parenteral administration may also include glycocholate for buccal administration, methoxysalicylate for rectal administration, or citric acid for vaginal administration.

The concentration of a neuregulin or a fragment or derivative thereof, or nucleic acid encoding such polypeptides, administered to a particular subject will vary depending upon a number of issues, including the condition being treated, the mode and site of administration, the age, weight sex and general health of the subject, and other such factors that are recognized by those skilled in the art. Optimal administration rates for a given protocol of administration can be readily determined by those skilled in the art.

All documents mentioned herein are incorporated herein by reference in their entirety. The invention is further illustrated by the following non-limiting Examples. Example 1 -- In vivo neuroprotection assay

Neuregulins and neuregulin fragments and derivatives can be assessed for neuroprotective efficacy pursuant to the following assay.

Mature male Long-Evans rats (Charles River, 250-350g) are allowed food and water *ad libitum*. Animals are anesthetized with sodium pentobarbital (60 mg/kg, i.p.) and placed in a stereotaxic head holder (David Kopf Instruments, Tujunga, CA). The

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dorsal surface of the skull is exposed by midline incision, and a small burr hole (2 mm diameter) is drilled over the right lateral ventricle, 1.6 mm lateral and 0.9 mm posterior to bregma. A stainless steel cannula (I.D. 0.020", O.D. 0.028", 2 cm long) is then inserted stereotaxically into the ventricle to a depth of 4.4 mm beneath the surface of the skull. The tubing is suitably bent at a 90° angle 1-1.6 cm from its tip and connected to polyethylene tubing (I.D. 0.76 mm, O.D. 1.22 mm, 10 cm long) that is connected (by glue) to a mini-osmotic pump (Alzet 1007D, 100 µl fill volume, pump rate = 0.5 µl/hr; Alza Corp., Palo Alto, CA) implanted subcutaneously in the back. The cannula can be suitably fixed to the skull by orthodontic resin (L.D. Culk Co., Milford, DE) bonded to two small machine screws (1/8" stainless steel slotted) inserted in the skull. The pump, tubing, and cannula are primed before insertion with infusate solutions; a 3-0 nylon suture is inserted into the cannula during implantation to prevent obstruction by brain tissue. The wound is closed with 3-0 silk suture and cefazolin (10 mg, i.m.) is administered. After surgery animals are suitably kept in individual cages and fed soft food.

Pumps are filled with vehicle alone (containing 127 mM NaCl, 2.6 mM KCl, 1.2 mM CaCl₂, 0.9 mM MgCl₂, 4.14 mM HEPES, 3 mM glycerin, 0.001% bovine serum albumin [BSA], and 0.01% fast green), or vehicle neuregulin or fragment or derivative thereof (100 µgm/ml). Heparin can be suitably used at relatively low doses, e.g. about 0.8 units/kg/day which is approximately 250-500 times less than a standard anticoagulant dose.

Three days after cannula implantation, animals are reanesthetized with 2% halothane and given atropine (0.15 mg/kg, i.p.). Animals are then intubated and connected to a ventilator (SAR-830; CWE Inc., Ardmore, PA) delivering 1% halothane/70% nitrous oxide in oxygen. The right femoral artery and vein are cannulated for monitoring of mean arterial blood pressure (MABP; Gould RS3200 Blood Pressure Monitor, Gould Inc., Valley View, OH), and blood sampling. Animals are then paralyzed with pancuronium bromide (0.5 mg/kg, i.v.). Arterial blood gasses (Corning 178 Blood Gas Analyzer, Ciba Corning Diagnostic Corp., Medford, MA), blood glucose (Accu-Check Blood Glucose Analyzer, Boehringer Mannheim, Indianapolis, IN), and hematocrit are measured at least twice during surgery and the immediate post-operative period. The stroke volume and rate of the

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ventilator are adjusted to maintain PaO₂ between 100-200 mm Hg and PaCO₂ between 30-40 mm Hg. Core body temperature may be monitored by rectal thermocouple (e.g. Model 73ATA, Yellow Springs Instrument Co., Yellow Springs, OH) and maintained between 36-37°C with a homeothermic blanket control unit (Harvard Bioscience, South Natick, MA).

Focal ischemic infarcts are made in the right lateral cerebral cortex in the territory of the middle cerebral artery (MCA) by the method of Chen, et al., *Stroke*, 17:738-743 (1986). Both common carotid arteries are exposed by midline anterior cervical incision. The animal is placed in a lateral position and a 1 cm skin incision is then made at the midpoint between the right lateral canthus and the anterior pinna. The temporal muscle is retracted, and a small (3 mm diameter) craniectomy is made at the junction of the zygoma and squamosal bone using a dental drill cooled with saline. Using a dissecting microscope, the dura can be opened with fine forceps, and the right MCA can be ligated with two 10-0 monofilament nylon ties just above the rhinal fissure and transected between the ties. Both common carotid arteries then can be occluded by microaneurysm clips for 45 minutes. After removal of the clips, return of flow is visualized in the arteries. Anesthesia is maintained for 15 minutes, and animals are returned to individual cages and fed soft food after surgery.

Twenty four hours after cerebral infarction, animals are again weighed, and then sacrificed by rapid decapitation. Brains are removed, inspected visually for the anatomy of the middle cerebral artery as well as for signs of hemorrhage or infection, immersed in cold saline for 10 minutes, and sectioned into six standard coronal slices (each 2 mm thick) using a rodent brain matrix slicer (Systems, Warren, MI). Brains are also examined visually for the presence of dye (fast green) in the cerebral ventricles. Slices are placed in the vital dye 2,3,5-triphenyl tetrazolium chloride (TTC, 2%; Chemical Dynamics Co., NH) at 37°C in the dark for 30 minutes, followed by 10% formalin at room temperature overnight. The outline of right and left cerebral hemispheres as well as that of infarcted tissue, clearly visualizable by lack of TTC staining (Chen et al., *Stroke*, 17:738-743 (1986)), is outlined on the posterior surface of each slice using an image analyzer (MTI videocamera and Sony video monitor connected to a Bioquant IV Image Analysis System run on an EVEREX computer). Infarct volume is calculated as the sum of infarcted area per slice multiplied by slice

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thickness. Both the surgeon and image analyzer operator are blinded to the treatment given each animal.

Volumes of infarcts among vehicle vs. neuregulin-treated animals can be compared by unpaired, two-tailed t-tests for each experiment, and by two-way analysis of variance (ANOVA; Exp. X Treatment) for combined data. A subsequent slice-by-slice analysis of infarct area among pooled neuregulin- vs. vehicle-treated animals is suitably done by repeated measures two-way ANOVA (Treatment X Slice). Other anatomical and physiological measurements are compared among GDF-1- vs. vehicle-treated animals by unpaired, two-tailed t-tests using the Bonferroni correction for multiple pairwise comparisons.

Example 2 -- In vivo behavioral assays

For behavioral outcome studies, such as to assess recovery, repair and remodeling promoted by administration of a neuregulin or fragment or derivative thereof, or nucleic acid encoding same, a number of assays can be employed such as those described in G. Sinson et al., *J Neurochem*, 65(5):2209-2214 (1995); T.K. McIntosh et al., *Neuroscience*, 28:233-244 (1989); and T.K. McIntosh et al., *J Neurotrauma*, 10:373-384 (1993).

Briefly, one suitable behavioral assay as described in G. Sinson et al., *supra*, entails that test animals (male Sprague-Dawley rats) receive preinjury training in a Morris Water Maze, a circular tank 1 m in diameter that is filled with 18°C water. The water surface is made opaque with a covering of Styrofoam pieces. During training of the animals a submerged platform is present in the maze. Each test animal undergoes 20 training trials over a two day period during which they learn to locate the platform using external visual cues. Immediately following the last training trial, animals are anesthetized and subjected to a lateral (parasagittal) fluid-percussion (FP) brain injury. Briefly, a 5-mm craniectomy is performed over the left parietal cortex, midway between lamda and bregma. A hollow Leur-loc fitting is cemented to the craniectomy site. The injury is delivered after attaching the FP device. The injury should be of moderate severity (2.1-2.3 atm). After injury, the Leur-loc is removed and the skin is sutured. Normothermia is maintained with warming pads until the animals being to ambulate.

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At 72 hours, 1 week or 2 weeks after injury, animals are assessed for their ability to remember the learned task of locating the platform in the MWM. For this evaluation the platform is removed from the maze, and the animal's swimming pattern is suitably recorded with a computerized video system for 1 minute. The maze is
5 separated in zones that are weighed according to the proximity to the platform's location. A memory score is generated by multiplying the weighted numbers by the time the animal spends in each zone and then adding the products.

Animals surviving for 1 or 2 weeks also can undergo evaluation of neurologic motor function. Briefly, one suitable assay provides that animals are scored from 0
10 (severely impaired) to 4 (normal) for each of the following: (1) left and (2) right forelimb during suspension by the tail; (3) left and (4) right hindlimb flexion when the forelimbs remain on a surface and the hindlimbs are lifted up and back by the tail; the ability to resist lateral pulsion to the (5) left and (6) right; and the ability to stand on an inclined plane in the (7) left, (8) right, and (9) vertical positions. Scores are
15 combined for each of the tests (1) through (9). The observer for the tests should be blinded to the animal's previous treatment.

The invention has been described in detail with reference to preferred embodiments thereof. However, it will be appreciated that those skilled in the art, upon consideration of this disclosure, may make modifications and improvements
20 within the spirit and scope of the invention.

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What is claimed is:

1. A method of treating a mammal suffering from or susceptible to stroke, brain or spinal cord injury or ischemia, or heart attack, comprising administering to the mammal a therapeutically effective amount of a neuregulin, or fragment or derivative of a neuregulin, or a nucleic acid encoding a neuregulin or a fragment or derivative of a neuregulin.

2. A method of treating a mammal suffering from or susceptible to optic nerve injury or retinal injury or ischemia, comprising administering to the mammal a therapeutically effective amount of a neuregulin, or fragment or derivative of a neuregulin, or a nucleic acid encoding a neuregulin or a fragment or derivative of a neuregulin.

3. A method of treating a mammal suffering from or susceptible to effects of post-surgical neurological deficits, hypoxia or hypoglycemia, comprising administering to the mammal a therapeutically effective amount of a neuregulin, or fragment or derivative of a neuregulin, or a nucleic acid encoding a neuregulin or a fragment or derivative of a neuregulin.

4. A method of treating a mammal suffering from or susceptible to epilepsy, Parkinson's disease, Huntington's disease, Amyotrophic Lateral Sclerosis, Alzheimer's disease, Down's Syndrome, Korsakoff's disease, or age-dependent dementia, comprising administering to the mammal a therapeutically effective amount of a neuregulin, or fragment or derivative of a neuregulin, or a nucleic acid encoding a neuregulin or a fragment or derivative of a neuregulin.

5. The method of claim 1 wherein the neuregulin, or fragment or derivative of a neuregulin, or a nucleic acid encoding a neuregulin or a fragment or derivative of a neuregulin is administered after the subject has suffered a stroke, brain or spinal cord injury or ischemia, or heart attack.

6. The method of claim 5 wherein the neuregulin, or fragment or derivative of a neuregulin, or a nucleic acid encoding a neuregulin or a fragment or derivative of a neuregulin is administered to the subject for at least about two weeks after the subject has suffered a stroke, brain or spinal cord injury or ischemia, or heart attack.

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7. A method of any one of claims 1-6 wherein a neuregulin or a fragment or derivative thereof is administered to the mammal.

8. A method of claim 7 wherein the neuregulin or fragment or derivative thereof comprises an amino acid sequence of the following formula:

WYBAZCX

wherein WYBAZCX is composed of amino acid sequences that include one or more sequences shown in FIGS. 1 through 15 (which includes SEQ ID NOS:2, 4, 5, 8, 9, 12, 14, 15, 18, 19, 22, 23, 26, 27, 30, 33, 35, 38, 39, 41, 44, 45 and 48), wherein W comprises the polypeptide segment F, or is absent; wherein Y comprises the polypeptide segment E, or is absent; wherein Z comprises the polypeptide segment G or is absent; and wherein X comprise a polypeptide segment selected from the group consisting of C/D HKL, C/D H, C/D HL, C/D D, C/D' HL, C/D' HKL, C/D' H, C/D' D, C/D C/D' HKL, C/D C/D' H, C/D C/D' HL, C/D C/D' D, C/D D'H, C/D D' HL, C/D D' HKL, C/D' D' H, C/D' D' HL, C/D' D' HKL, C/D C/D' D' H, C/D C/D' D' HL and C/D C/D' D' HKL, and preferably that either

- a) at least one of F, Y, B, A, Z, C or X is of bovine origin; or
- b) Y comprises the polypeptide segment E; or
- c) X comprises the polypeptide segments C/D HKL, C/D D, C/D' HKL, C/D C/D' HKL, C/D C/D' D, C/D D' H, C/D D' HL, C/D D' HKL, C/D' D' H, C/D' D' HKL, C/D C/D' D'H, C/D C/D' D HL, C/D C/D' D' HKL, C/D'H, C/D C/D' H or C/D C/D' HL.

9. The method of claim 7 wherein the neuregulin or fragment or derivative thereof a) has at least one of F, Y, B, A, Z, C or X is of bovine origin; or b) Y comprises the polypeptide segment E; or c) X comprises the polypeptide segments C/D HKL, C/D D, C/D' HKL, C/D C/D' HKL, C/D C/D' D, C/D D H, C/D D' HL, C/D D' HKL, C/D C/D' D' H, C/D C/D' D HL, C/D C/D' D' HKL, C/D'H, C/D C/D' H or C/D C/D' HL.

10. The method of claim 7 wherein the neuregulin or fragment or derivative thereof comprises FBA polypeptide segments, FEBA polypeptides segments, EBA polypeptide segments, EBA' polypeptide segments or FEBA' polypeptide segments.

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11. A method of claim 7 wherein the neuregulin is encoded by a nucleic acid that comprises one of SEQ ID NOS:49, 51 and 53.

12. A method of claim 7 wherein the neuregulin or fragment or derivative thereof is encoded by a nucleic acid that comprises a sequence that has at least about 70% sequence identity to one of SEQ ID NOS:49, 51 and 53.

13. A method of claim 7 wherein the neuregulin or fragment or derivative thereof is encoded by a sequence that hybridizes to one of SEQ ID NOS:49, 51 or 53 under normal stringency conditions.

14. A method of claim 7 wherein the neuregulin or fragment or derivative thereof is encoded by a sequence that hybridizes to one of SEQ ID NOS:49, 51 or 53 under high stringency conditions.

15. A method of claim 7 wherein the neuregulin or fragment or derivative has at least about 70% sequence identity to SEQ ID NOS:50, 52 or 54.

16. A method of claim 7 wherein the neuregulin or fragment or derivative thereof is encoded by a nucleic acid that comprises a sequence that has at least about 70% sequence identity to one of SEQ ID NO:20 (Figure 7); SEQ ID NO:21 (Figure 7); SEQ ID NO:24 (Figure 8); SEQ ID NO:25 (Figure 8); SEQ ID NO:28 (Figure 9); or SEQ ID NO:29 (Figure 9).

17. A method of claim 7 wherein the neuregulin or fragment or derivative thereof is encoded by a sequence that hybridizes to one of SEQ ID NO:20 (Figure 7); SEQ ID NO:21 (Figure 7); SEQ ID NO:24 (Figure 8); SEQ ID NO:25 (Figure 8); SEQ ID NO:28 (Figure 9); or SEQ ID NO:29 (Figure 9) under normal stringency conditions.

18. A method of claim 7 wherein the neuregulin or fragment or derivative comprises a sequence that has at least about 70% sequence identity to any of the peptide sequences shown in Figures 7, 8 or 9 of the drawings.

19. A method of claim 7 where the neuregulin or fragment or derivative comprises a sequence that has at least about 80 percent homology to any of the peptide sequences shown in Figures 7, 8 or 9.

20. A method of claim 7 where the neuregulin or fragment or derivative comprises a sequence that has at least about 90 percent homology to any of the peptide sequences shown in Figures 7, 8 or 9.

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21. A method of claim 7 wherein the neuregulin or fragment or derivative comprises a sequence that has at least about 95 percent homology to any of the peptide sequences shown in Figures 7, 8 or 9.

22. A method of claim 7 wherein the neuregulin or fragment or derivative comprises a sequence that is shown in Figures 7, 8 or 9.

23. A method of any one of claims 1-6 wherein a nucleic acid encoding a neuregulin or a fragment or derivative thereof is administered to the mammal.

24. A method of claim 23 wherein the nucleic acid is SEQ ID NO:49, 51 or 53, or the complement thereof.

25. A method of claim 23 wherein the nucleic or fragment or derivative thereof encodes a neuregulin or neuregulin fragment or derivative that comprises an amino acid sequence of the following formula:

WYBAZCX

wherein WYBAZCX is composed of amino acid sequences that include one or more sequences shown in FIGS. 1 through 15 (which includes SEQ ID NOS:2, 4, 5, 8, 9, 12, 14, 15, 18, 19, 22, 23, 26, 27, 30, 33, 35, 38, 39, 41, 44, 45 and 48), wherein W comprises the polypeptide segment F, or is absent, wherein Y comprises the polypeptide segment E, or is absent; wherein Z comprises the polypeptide segment G or is absent; and wherein X comprise a polypeptide segment selected from the group consisting of C/D HKL, C/D H, C/D HL, C/D D, C/D' HL, C/D' HKL, C/D' H, C/D' D, C/D C/D' HKL, C/D C/D' H, C/D C/D' HL, C/D C/D' D, C/D D' HL, C/D D' HKL, C/D' D' H, C/D' D' HL, C/D' D' HKL, C/D C/D' D' H, C/D C/D' D' HL and C/D C/D' D' HKL.

26. The method of claim 25 wherein the neuregulin or neuregulin fragment or derivative a) has at least one of F, Y, B, A, Z, C or X is of bovine origin; or b) Y comprises the polypeptide segment E; or c) X comprises the polypeptide segments C/D HKL, C/D D, C/D' HKL, C/D C/D' HKL, C/D C/D' D, C/D D H, C/D D' HL, C/D D' HKL, C/D C/D' D' H, C/D C/D' D HL, C/D C/D' D' HKL, C/D'H, C/D C/D' H or C/D C/D' HL.

27. The method of claim 25 wherein the neuregulin or neuregulin fragment or derivative comprises FBA polypeptide segments, FEBA polypeptides segments,

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EBA polypeptide segments, EBA' polypeptide segments or FEBA' polypeptide segments.

28. A method of claim 23 wherein the nucleic acid comprises a sequence that hybridizes to SEQ ID NO:20 (Figure 7); SEQ ID NO:21 (Figure 7); SEQ ID NO:24 (Figure 8); SEQ ID NO:25 (Figure 8); SEQ ID NO:28 (Figure 9); or SEQ ID NO:29 (Figure 9) under normal stringency conditions.

29. A method of claim 23 wherein the nucleic acid comprises a sequence that hybridizes to SEQ ID NO:20 (Figure 7); SEQ ID NO:21 (Figure 7); SEQ ID NO:24 (Figure 8); SEQ ID NO:25 (Figure 8); SEQ ID NO:28 (Figure 9); or SEQ ID NO:29 (Figure 9) under high stringency conditions.

30. A method of claim 23 wherein the nucleic acid comprises a sequence that has at least about 70 percent homology to any of the nucleic acid sequences shown in Figures 7, 8 or 9.

31. A method of claim 23 wherein the nucleic acid comprises a sequence that has at least about 80 percent homology to any of the nucleic acid sequences shown in Figures 7, 8 or 9.

32. A method of claim 23 wherein the nucleic acid comprises a sequence that has at least about 90 percent homology to any of the nucleic acid sequences shown in Figures 7, 8 or 9.

33. A method of claim 23 wherein the nucleic acid comprises a sequence that has at least about 95 percent homology to any of the nucleic acid sequences shown in Figures 7, 8 or 9.

34. A method of claim 23 wherein the nucleic acid comprises a sequence shown in Figures 7, 8 or 9.

35. A method of any one of claims 1-34 wherein the administered neuregulin fragment or derivative, or the administered nucleic acid encodes a neuregulin fragment or derivative exhibits at least about a 10% reduction in infarct volume in an *in vivo* cerebral ischemia assay.

36. A method of any one of claims 1-35 wherein the mammal is a human.

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FIG. 1A
HUMAN SEGMENT E: (SEQ ID NOS:1-2)

ATG AGA TGG CGA CGC GCC CCG CGC CGC TCC GGG CGT CCC GGC CCC CGG	48
Met Arg Trp Arg Arg Ala Pro Arg Arg Ser Gly Arg Pro Gly Pro Arg	
1 5 10 15	
GCC CAG CGC CCC GGC TCC GCC GCC CGC TCG TCG CCG CCG CTG CCG CTG	96
Ala Gln Arg Pro Gly Ser Ala Ala Arg Ser Ser Pro Pro Leu Pro Leu	
20 25 30	
CTG CCA CTA CTG CTG CTG CTG GGG ACC GCG GCC CTG GCG CCG GGG GCG	144
Leu Pro Leu Leu Leu Leu Leu Gly Thr Ala Ala Leu Ala Pro Gly Ala	
35 40 45	
GCG GCC GGC AAC GAG GCG GCT CCC GCG GGG GCC TCG GTG TGC TAC TCG	192
Ala Ala Gly Asn Glu Ala Ala Pro Ala Gly Ala Ser Val Cys Tyr Ser	
50 55 60	
TCC CCG CCC AGC GTG GGA TCG GTG CAG GAG CTA GCT CAG CGC GCC GCG	240
Ser Pro Pro Ser Val Gly Ser Val Gln Glu Leu Ala Gln Arg Ala Ala	
65 70 75 80	
GTG GTG ATC GAG GGA AAG GTG CAC CCG CAG CGG CGG CAG CAG GGG GCA	288
Val Val Ile Glu Gly Lys Val His Pro Gln Arg Arg Gln Gln Gly Ala	
85 90 95	
CTC GAC AGG AAG GCG GCG GCG GCG GCG GGC GAG GCA GGG GCG TGG GGC	336
Leu Asp Arg Lys Ala Ala Ala Ala Ala Gly Glu Ala Gly Ala Trp Gly	
100 105 110	
GGC GAT CGC GAG CCG CCA GCC GCG GGC CCA CGG GCG CTG GGG CCG CCC	384
Gly Asp Arg Glu Pro Pro Ala Ala Gly Pro Arg Ala Leu Gly Pro Pro	
115 120 125	
GCC GAG GAG CCG CTG CTC GCC GCC AAC GGG ACC GTG CCC TCT TGG CCC	432
Ala Glu Glu Pro Leu Leu Ala Ala Asn Gly Thr Val Pro Ser Trp Pro	
130 135 140	
ACC GCC CCG GTG CCC AGC GCC GGC GAG CCC GGG GAG GAG GCG CCC TAT	480
Thr Ala Pro Val Pro Ser Ala Gly Glu Pro Gly Glu Glu Ala Pro Tyr	
145 150 155 160	
CTG GTG AAG GTG CAC CAG GTG TGG GCG GTG AAA GCC GGG GGC TTG AAG	528
Leu Val Lys Val His Gln Val Trp Ala Val Lys Ala Gly Gly Leu Lys	
165 170 175	
AAG GAC TCG CTG CTC ACC GTG CGC CTG GGG ACC TGG GGC CAC CCC GCC	576
Lys Asp Ser Leu Leu Thr Val Arg Leu Gly Thr Trp Gly His Pro Ala	
180 185 190	

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FIG. 1B

TTC	CCC	TCC	TGC	GGG	AGG	CTC	AAG	GAG	GAC	AGC	AGG	TAC	ATC	TTC	TTC	624
Phe	Pro	Ser	Cys	Gly	Arg	Leu	Lys	Glu	Asp	Ser	Arg	Tyr	Ile	Phe	Phe	
		195					200					205				
ATG	GAG	CCC	GAC	GCC	AAC	AGC	ACC	AGC	CGC	GCG	CCG	GCC	GCC	TTC	CGA	672
Met	Glu	Pro	Asp	Ala	Asn	Ser	Thr	Ser	Arg	Ala	Pro	Ala	Ala	Phe	Arg	
	210					215					220					
GCC	TCT	TTC	CCC	CCT	CTG	GAG	ACG	GGC	CGG	AAC	CTC	AAG	AAG	GAG	GTC	720
Ala	Ser	Phe	Pro	Pro	Leu	Glu	Thr	Gly	Arg	Asn	Leu	Lys	Lys	Glu	Val	
225					230					235					240	
AGC	CGG	GTG	CTG	TGC	AAG	CGG	TGC	G								745
Ser	Arg	Val	Leu	Cys	Lys	Arg	Cys									
				245												

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FIG. 2
SEGMENT E: (SEQ ID NOS:3-4)

CC CAT CAA GTG TGG GCG GCG AAA GCC GGG GGC TTG AAG AAG GAC TCG	47
His Gln Val Trp Ala Ala Lys Ala Gly Gly Leu Lys Lys Asp Ser	
1 5 10 15	
CTG CTC ACC GTG CGC CTG GGC GCC TGG GGC CAC CCC GCC TTC CCC TCC	95
Leu Leu Thr Val Arg Leu Gly Ala Trp Gly His Pro Ala Phe Pro Ser	
20 25 30	
TGC GGG CGC CTC AAG GAG GAC AGC AGG TAC ATC TTC TTC ATG GAG CCC	143
Cys Gly Arg Leu Lys Glu Asp Ser Arg Tyr Ile Phe Phe Met Glu Pro	
35 40 45	
GAG GCC AAC AGC AGC GGC GGG CCC GGC CGC CTT CCG AGC CTC CTT CCC	191
Glu Ala Asn Ser Ser Gly Gly Pro Gly Arg Leu Pro Ser Leu Leu Pro	
50 55 60	
CCC TCT CGA GAC GGG CCG GAA CCT CAA GAA GGA GGT CAG CCG GGT GCT	239
Pro Ser Arg Asp Gly Pro Glu Pro Gln Glu Gly Gly Gln Pro Gly Ala	
65 70 75	
GTG CAA CGG TGC G	252
Val Gln Arg Cys	
80	

FIG. 3
SEGMENT B: (SEQ ID NOS:5-8)

Leu Pro Pro Arg Leu Lys Glu His Lys Ser Gln Glu Ser Val Ala Gly	48
CCT TGC CTC CCC GCT TGA AAG AGA TGA AGA GTC AGG AGT CTG TGG CAG	
CCT TGC CTC CCC GAT TGA AAG AGA TGA AAA GCC AGG AAT CGG CTG CAG	
Q A	
Ser Lys Leu Val Leu Arg Cys Glu Thr Ser Ser Glu Tyr Ser Ser Leu	96
GTT CCA AAC TAG TGC TTC GGT GCG AGA CCA GTT CTG AAT ACT CCT CTC	
GTT CCA AAC TAG TCC TTC GGT GTG AAA CCA GTT CTG AAT ACT CCT CTC	
Lys Phe Lys Trp Phe Lys Asn Gly Ser Glu Leu Ser Arg Lys Asn Lys	144
TCA AGT TCA AGT GGT TCA AGA ATG GGA GTG AAT TAA GCC GAA AGA ACA	
TCA GAT TCA AGT GGT TCA AGA ATG GGA ATG AAT TGA ATC GAA AAA ACA	
R N N	
Pro Gly Asn Ile Lys Ile Gln Lys Arg Pro Gly	178
AAC CAC AAA ACA TCA AGA TAC AGA AAA GGC CGG G	
AAC CAC AAA ATA TCA AGA TAC AAA AAA AGC CAG G	
K	

FIG 4
SEGMENT A: (SEQ ID NOS:9-12)

Lys	Ser	Glu	Leu	Arg	Ile	Ser	Lys	Ala	Ser	Leu	Ala	Asp	Ser	Gly	
G	AAG	TCA	GAA	CTT	CGC	ATT	AGC	AAA	GCG	TCA	CTG	GCT	GAT	TCT	GGA
G	AAG	TCA	GAA	CTT	CGC	ATT	AAC	AAA	GCA	TCA	CTG	GCT	GAT	TCT	GGA
							N								

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Glu	Tyr	Met	Cys	Lys	Val	Ile	Ser	Lys	Leu	Gly	Asn	Asp	Ser	Ala	Ser
GAA	TAT	ATG	TGC	AAA	GTG	ATC	AGC	AAA	CTA	GGA	AAT	GAC	AGT	GCC	TCT
GAG	TAT	ATG	TGC	AAA	GTG	ATC	AGC	AAA	TTA	GGA	AAT	GAC	AGT	GCC	TCT

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Ala	Asn	Ile	Thr	Ile	Val	Glu	Ser	Asn	Ala						
GCC	AAC	ATC	ACC	ATT	GTG	GAG	TCA	AAC	G						
GCC	AAT	ATC	ACC	ATC	GTG	GAA	TCA	AAC	G						

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FIG.5
SEGMENT A': (SEQ ID NOS:13-14)

TCTAAACTA	CAGAGACTGT	ATTTTCATGA	TCATCATAGT	TCTGTGAAAT	ATACTTAAAC	
						60
CGCTTTGGTC	CTGATCTTGT	AGG	AAG	TCA	GAA	CTT
			Lys	Ser	Glu	Leu
			1			5
TCA	CTG	GCT	GAT	TCT	GGA	GAA
Ser	Leu	Ala	Asp	Ser	Gly	Glu
10					15	20
						25
GGA	AAT	GAC	AGT	GCC	TCT	GCC
Gly	Asn	Asp	Ser	Ala	Ser	Ala
			30			35
						40
AAG	AGA	TGC	CTA	CTG	CGT	GCT
Lys	Arg	Cys	Leu	Leu	Arg	Ala
			45			50
						55
AAG	GTA	TGT	GGT	CAC	ACT	TGAATCACGC
Lys	Val	Cys	Gly	His	Thr	
			60			
TGAACAAATA	AAAATCATGA	AAGGAAAAC	CTATGTTTGA	AATATCTTAT	GGGTCTCCT	
						362
GTAAGCTCT	TCACTCCATA	AGGTGAAATA	GACCTGAAAT	ATATATAGAT	TATTT	
						417

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FIG. 6
SEGMENT G: (SEQ ID NOS:15-18)

Glu	Ile	Thr	Thr	Gly	Met	Pro	Ala	Ser	Thr	Glu	Thr	Ala	Tyr	Val	Ser			47
AG	ATC	ACC	ACT	GGC	ATG	CCA	GCC	TCA	ACT	GAG	ACA	GCG	TAT	GTG	TCT			
AG	ATC	ATC	ACT	GGT	ATG	CCA	GCC	TCA	ACT	GAA	GGA	GCA	TAT	GTG	TCT			
			I								G							
Ser	Glu	Ser	Pro	Ile	Arg	Ile	Ser	Val	Ser	Thr	Glu	Gly	Thr	Asn	Thr			95
TCA	GAG	TCT	CCC	ATT	AGA	ATA	TCA	GTA	TCA	ACA	GAA	GGA	ACA	AAT	ACT			
TCA	GAG	TCT	CCC	ATT	AGA	ATA	TCA	GTA	TCC	ACA	GAA	GGA	GCA	AAT	ACT			
													A					
Ser	Ser	Ser																102
TCT	TCA	T																
TCT	TCA	T																

FIG. 7
SEGMENT C: (SEQ ID NOS:19-22)

Thr	Ser	Thr	Ser	Thr	Ala	Gly	Thr	Ser	His	Leu	Val	Lys	Cys	Ala				47
CC	ACA	TCC	ACA	TCT	ACA	GCT	GGG	ACA	AGC	CAT	CTT	GTC	AAG	TGT	GCA			
CT	ACA	TCT	ACA	TCC	ACC	ACT	GGG	ACA	AGC	CAT	CTT	GTA	AAA	TGT	GCG			
					T													
Glu	Lys	Glu	Lys	Thr	Phe	Cys	Val	Asn	Gly	Gly	Glu	Cys	Phe	Met	Val			95
GAG	AAG	GAG	AAA	ACT	TTC	TGT	GTG	AAT	GGA	GGC	GAG	TGC	TTC	ATG	GTG			
GAG	AAG	GAG	AAA	ACT	TTC	TGT	GTG	AAT	GGA	GGG	GAG	TGC	TTC	ATG	GTG			
Lys	Asp	Leu	Ser	Asn	Pro	Ser	Arg	Tyr	Leu	Cys								128
AAA	GAC	CTT	TCA	AAT	CCC	TCA	AGA	TAC	TTG	TGC								
AAA	GAC	CTT	TCA	AAC	CCC	TCG	AGA	TAC	TTG	TGC								

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FIG. 8
SEGMENT C/D: (SEQ ID NOS:23-26)

Lys	Cys	Gln	Pro	Gly	Phe	Thr	Gly	Ala	Arg	Cys	Thr	Glu	Asn	Val	Pro		48
AAG	TGC	CAA	CCT	GGA	TTC	ACT	GGA	GCG	AGA	TGT	ACT	GAG	AAT	GTG	CCC		
AAG	TGC	CAA	CCT	GGA	TTC	ACT	GGA	GCA	AGA	TGT	ACT	GAG	AAT	GTG	CCC		
Met	Lys	Val	Gln	Thr	Gln	Glu											
ATG	AAA	GTC	CAA	ACC	CAA	GAA											69
ATG	AAA	GTC	CAA	AAC	CAA	GAA											
				N													

FIG. 9
SEGMENT C/D': (SEQ ID NOS:27-29)

Lys	Cys	Pro	Asn	Glu	Phe	Thr	Gly	Asp	Arg	Cys	Gln	Asn	Tyr	Val	Met		48
AAG	TGC	CCA	AAT	GAG	TTT	ACT	GGT	GAT	CGC	TGC	CAA	AAC	TAC	GTA	ATG		
AAG	TGC	CCA	AAT	GAG	TTT	ACT	GGT	GAT	CGC	TGC	CAA	AAC	TAC	GTA	ATG		
Ala	Ser	Phe	Tyr														
GCC	AGC	TTC	TAC														60
GCC	AGC	TTC	TAC														

FIG. 10
SEGMENT D: (SEQ ID NOS:30-32)

Ser	Thr	Ser	Thr	Pro	Phe	Leu	Ser	Leu	Pro	Glu	*			36
AGT	ACG	TCC	ACT	CCC	TTT	CTG	TCT	CTG	CCT	GAA	TAG			
AGT	ACG	TCC	ACT	CCC	TTT	CTG	TCT	CTG	CCT	GAA	TAG			

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FIG. 12B

Thr	Val	Thr	Gln	Thr	Pro	Ser	His	Ser	Trp	Ser	Asn	Gly	His	Thr	Glu	
ACT	GTC	ACT	CAG	ACT	CCC	AGT	CAC	AGC	TGG	AGC	AAT	GGA	CAC	ACT	GAA	384
ACT	GTC	ACC	CAG	ACT	CCT	AGC	CAC	AGC	TGG	AGC	AAC	GGA	CAC	ACT	GAA	
Ser	Ile	Ile	Ser	Glu	Ser	His	Ser	Val	Ile	Val	Met	Ser	Ser	Val	Glu	
AGC	ATC	ATT	TCG	GAA	AGC	CAC	TCT	GTC	ATC	GTG	ATG	TCA	TCC	GTA	GAA	432
AGC	ATC	CTT	TCC	GAA	AGC	CAC	TCT	GTA	ATC	GTG	ATG	TCA	TCC	GTA	GAA	
		L														
Asn	Ser	Arg	His	Ser	Ser	Pro	Thr	Gly	Gly	Pro	Arg	Gly	Arg	Leu	Asn	
AAC	AGT	AGG	CAC	AGC	AGC	CCG	ACT	GGG	GGC	CCG	AGA	GGA	CGT	CTC	AAT	480
AAC	AGT	AGG	CAC	AGC	AGC	CCA	ACT	GGG	GGC	CCA	AGA	GGA	CGT	CTT	AAT	
Gly	Leu	Gly	Gly	Pro	Arg	Glu	Cys	Asn	Ser	Phe	Leu	Arg	His	Ala	Arg	
GGC	TTG	GGA	GGC	CCT	CGT	GAA	TGT	AAC	AGC	TTC	CTC	AGG	CAT	GCC	AGA	528
GGC	ACA	GGA	GGC	CCT	CGT	GAA	TGT	AAC	AGC	TTC	CTC	AGG	CAT	GCC	AGA	
T																
Glu	Thr	Pro	Asp	Ser	Tyr	Arg	Asp	Ser	Pro	His	Ser	Glu	Arg			
GAA	ACC	CCT	GAC	TCC	TAC	CGA	GAC	TCT	CCT	CAT	AGT	GAA	AG			569
GAA	ACC	CCT	GAT	TCC	TAC	CGA	GAC	TCT	CCT	CAT	AGT	GAA	AG			

FIG. 13

SEGMENT K: (SEQ ID NOS:39-40)

A	CAT	AAC	CTT	ATA	GCT	GAG	CTA	AGG	AGA	AAC	AAG	GCC	CAC	AGA	TCC	46
	His	Asn	Leu	Ile	Ala	Glu	Leu	Arg	Arg	Asn	Lys	Ala	His	Arg	Ser	
	1				5					10					15	
AAA	TGC	ATG	CAG	ATC	CAG	CTT	TCC	GCA	ACT	CAT	CTT	AGA	GCT	TCT	TCC	94
Lys	Cys	Met	Gln	Ile	Gln	Leu	Ser	Ala	Thr	His	Leu	Arg	Ala	Ser	Ser	
			20						25					30		
ATT	CCC	CAT	TGG	GCT	TCA	TTC	TCT	AAG	ACC	CCT	TGG	CCT	TTA	GGA	AG	141
Ile	Pro	His	Trp	Ala	Ser	Phe	Ser	Lys	Thr	Pro	Trp	Pro	Leu	Gly	Arg	
			35					40					45			

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FIG. 14A
SEGMENT L: (SEQ ID NOS:41-44)

Tyr Val Ser Ala Met Thr Thr Pro Ala Arg Met Ser Pro Val Asp	
G TAT GTA TCA GCA ATG ACC ACC CCG GCT CGT ATG TCA CCT GTA GAT	46
G TAT GTG TCA GCC ATG ACC ACC CCG GCT CGT ATG TCA CCT GTA GAT	
Phe His Thr Pro Ser Ser Pro Lys Ser Pro Pro Ser Glu Met Ser Pro	
TTC CAC ACG CCA AGC TCC CCC AAG TCA CCC CCT TCG GAA ATG TCC CCG	94
TTC CAC ACG CCA AGC TCC CCC AAA TCG CCC CCT TCG GAA ATG TCT CCA	
Pro Val Ser Ser Thr Thr Val Ser Met Pro Ser Met Ala Val Ser Pro	
CCC GTG TCC AGC ACG ACG GTC TCC ATG CCC TCC ATG GCG GTC AGT CCC	142
CCC GTG TCC AGC ATG ACG GTG TCC ATG CCT TCC ATG GCG GTC AGC CCC	
M	
Phe Val Glu Glu Glu Arg Pro Leu Leu Leu Val Thr Pro Pro Arg Leu	
TTC GTG GAA GAG GAG AGA CCC CTG CTC CTT GTG ACG CCA CCA CGG CTG	190
TTC ATG GAA GAA GAG AGA CCT CTA CTT CTC GTG ACA CCA CCA AGG CTG	
N	
Arg Glu Lys - Tyr Asp His His Ala Gln Gln Phe Asn Ser Phe His	
CGG GAG AAG ... TAT GAC CAC CAC GCC CAG CAA TTC AAC TCG TTC CAC	238
CGG GAG AAG AAG TTT GAC CAT CAC CCT CAG CAG TTC AGC TCC TTC CAC	
K F P	
Cys Asn Pro Ala His Glu Ser Asn Ser Leu Pro Pro Ser Pro Leu Arg	
TGC AAC CCC GCG CAT GAG AGC AAC AGC CTG CCC CCC AGC CCC TTG AGG	286
CAC AAC CCC GCG CAT GAC AGT AAC AGC CTC CCT GCT AGC CCC TTG AGG	
N D A	
Ile Val Glu Asp Glu Glu Tyr Glu Thr Thr Gln Glu Tyr Glu Pro Ala	
ATA GTG GAG GAT GAG GAA TAT GAA ACG ACC CAG GAG TAC GAA CCA GCT	334
ATA GTG GAG GAT GAG GAG TAT GAA ACG ACC CAA GAG TAC GAG CCA GCC	
Gln Glu Pro Val Lys Lys Leu Thr Asn Ser Ser Arg Arg Ala Lys Arg	
CAA GAG CCG GTT AAG AAA CTC ACC AAC AGC AGC CGG CGG GCC AAA AGA	382
CAA GAG CCT GTT AAG AAA CTC GCC AA. .T AGC CGG CGG GCC AAA AGA	
A	

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FIG. 14B

Thr	Lys	Pro	Asn	Gly	His	Ile	Ala	His	Arg	Leu	Glu	Met	Asp	Asn	Asn	
ACC	AAG	CCC	AAT	GGT	CAC	ATT	GCC	CAC	AGG	TTG	GAA	ATG	GAC	AAC	AAC	430
ACC	AAG	CCC	AAT	GGC	CAC	ATT	GCT	N	AGA	TTG	GAA	V	GAC	S	AAC	
Thr	Gly	Ala	Asp	Ser	Ser	Asn	Ser	Glu	Ser	Glu	Thr	Glu	Asp	Glu	Arg	
ACA	GGC	GCT	GAC	AGC	AGT	AAC	TCA	GAG	AGC	GAA	ACA	GAG	GAT	GAA	AGA	478
ACA	AGC	TCC	CAG	AGC	AGT	AAC	TCA	GAG	AGT	GAA	ACA	GAA	GAT	GAA	AGA	
	S	S	Q													
Val	Gly	Glu	Asp	Thr	Pro	Phe	Leu	Ala	Ile	Gln	Asn	Pro	Leu	Ala	Ala	
GTA	GGA	GAA	GAT	ACG	CCT	TTC	CTG	GCC	ATA	CAG	AAC	CCC	CTG	GCA	GCC	526
GTA	GGT	GAA	GAT	ACG	CCT	TTC	CTG	G	ATA	CAG	AAC	CCC	CTG	GCA	GCC	
Ser	Leu	Glu	Ala	Ala	Pro	Ala	Phe	Arg	Leu	Val	Asp	Ser	Arg	Thr	Asn	
AGT	CTC	GAG	GCG	GCC	CCT	GCC	TTC	CGC	CTG	GTC	GAC	AGC	AGG	ACT	AAC	574
AGT	CTT	GAG	GCA	ACA	CCT	GCC	TTC	CGC	CTG	GCT	GAC	AGC	AGG	ACT	AAC	
				T						A						
Pro	Thr	Gly	Gly	Phe	Ser	Pro	Gln	Glu	Glu	Leu	Gln	Ala	Arg	Leu	Ser	
CCA	ACA	GGC	GGC	TTC	TCT	CCG	CAG	GAA	GAA	TTG	CAG	GCC	AGG	CTC	TCC	622
CCA	GCA	GGC	CGC	TTC	TCG	ACA	CAG	GAA	GAA	ATC	CAG	GCC	AGG	CTG	TCT	
	A		R			T				I						
Gly	Val	Ile	Ala	Asn	Gln	Asp	Pro	Ile	Ala	Val	*					
GGT	GTA	ATC	GCT	AAC	CAA	GAC	CCT	ATC	GCT	GTC	TAA	AAC	CGA	AAT	ACA	670
AGT	GTA	ATT	GCT	AAC	CAA	GAC	CCT	ATT	GCT	GTA	TAA	AAC	CTA	AAT	AAA	
CCC	ATA	GAT	TCA	CCT	GTA	AAA	CTT	TAT	TTT	ATA	TAA	TAA	AGT	ATT	CCA	718
CAC	ATA	GAT	TCA	CCT	GTA	AAA	CTT	TAT	TTT	ATA	TAA	TAA	AGT	ATT	CCA	
CCT	TAA	ATT	AAA	CAA												733
CCT	TAA	ATT	AAA	CAA												

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FIG. 15
SEGMENT F: (SEQ ID NOS:45-48)

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AGTTTCCCCC CCCAACTTGT CGGAACTCTG GGCTCGCGCG CAGGGCAGGA GCGGAGCGGC      60
GGCGGCTGCC CAGGCGATGC GAGCGCGGGC CGGACGGTAA TCGCCTCTCC CTCCTCGGGC      120
TGCAGCGCGC CCGGACCGAG GCAGCGACAG GAGCGGACCG CGGCGGGAAC CGAGGACTCC      180
CCAGCGGCGC GCCAGCAGGA GCCACCCCGC GAGNCGTGCG ACCGGGACGG AGCGCCCGCC      240
AGTCCCAGGT GGCCCGGACC GCACGTTGCG TCCCCGCGCT CCCC GCCGGC GACAGGAGAC      300
GCTCCCCCCC ACGCCGCGCG CGCCTCGGCC CGGTCGCTGG CCCGCTCCA CTCCGGGGAC      360
          ||||| ||||| ||||| ||||| ||||| ||||| ||||| |||||
          CGCGAG CGCCTCAGCG CGGCCGCTCG CTCTC..CCC CTCGAGGGAC

AAACTTTTCC CGAAGCCGAT CCCAGCCCTC GGACCCAAAC TTGTCGCGCG TCGCCTTCGC      420
AAACTTTTCC CAAACCCGAT CCGAGCCCTT GGACCAA... ..C TCGCCTGCGC

                                     Met Ser Glu Arg Arg
CGGGAGCCGT CCGCGCAGAG CGTGCACTTC TCGGGCGAG ATG TCG GAG CGC AGA      474
||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| |||||
CGAGAGCCGT CCGCGTAGAG CGCTC.CGTC TCCGGCGAG ATG TCC GAG CGC AAA
                                     K

Glu Gly Lys Gly Lys Gly Lys Gly Gly Lys Lys Asp Arg Gly Ser Gly
GAA GGC AAA GGC AAG GGG AAG GGC GGC AAG AAG GAC CGA GGC TCC GGG      522
||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| |||||
GAA GGC AGA GGC AAA GGG AAG GGC AAG AAG AAG GAG CGA GGC TCC GGC
          R                               K                               E

Lys Lys Pro Val Pro Ala Ala Gly Gly Pro Ser Pro Ala
AAG AAG CCC GTG CCC GCG GCT GGC GGC CCG AGC CCA G
||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| ||||| |||||
AAG AAG CCG GAG TCC GCG GCG GGC AGC CAG AGC CCA G
          E       S

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FIG. 16A
(SEQ ID NOS:49-50)

G AAG TCA GAA CTT CGC ATT AGC AAA GCG TCA CTG GCT GAT TCT GGA GAA	49
Lys Ser Glu Leu Arg Ile Ser Lys Ala Ser Leu Ala Asp Ser Gly Glu	
1 5 10 15	
TAT ATG TGC AAA GTG ATC AGC AAA CTA GGA AAT GAC AGT GCC TCT GCC	97
Tyr Met Cys Lys Val Ile Ser Lys Leu Gly Asn Asp Ser Ala Ser Ala	
20 25 30	
AAC ATC ACC ATT GTG GAG TCA AAC GCC ACA TCC ACA TCT ACA GCT GGG	145
Asn Ile Thr Ile Val Glu Ser Asn Ala Thr Ser Thr Ser Thr Ala Gly	
35 40 45	
ACA AGC CAT CTT GTC AAG TGT GCA GAG AAG GAG AAA ACT TTC TGT GTG	193
Thr Ser His Leu Val Lys Cys Ala Glu Lys Glu Lys Thr Phe Cys Val	
50 55 60	
AAT GGA GGC GAC TGC TTC ATG GTG AAA GAC CTT TCA AAT CCC TCA AGA	241
Asn Gly Gly Asp Cys Phe Met Val Lys Asp Leu Ser Asn Pro Ser Arg	
65 70 75 80	
TAC TTG TGC AAG TGC CAA CCT GGA TTC ACT GGA GCG AGA TGT ACT GAG	289
Tyr Leu Cys Lys Cys Gln Pro Gly Phe Thr Gly Ala Arg Cys Thr Glu	
85 90 95	
AAT GTG CCC ATG AAA GTC CAA ACC CAA GAA AAA GCG GAG GAG CTC TAC	337
Asn Val Pro Met Lys Val Gln Thr Gln Glu Lys Ala Glu Glu Leu Tyr	
100 105 110	
CAG AAG AGA GTG CTC ACC ATT ACC GGC ATT TGC ATC GCG CTG CTC GTG	385
Gln Lys Arg Val Leu Thr Ile Thr Gly Ile Cys Ile Ala Leu Leu Val	
115 120 125	
GTT GGC ATC ATG TGT GTG GTG GTC TAC TGC AAA ACC AAG AAA CAA CGG	433
Val Gly Ile Met Cys Val Val Val Tyr Cys Lys Thr Lys Lys Gln Arg	
130 135 140	
AAA AAG CTT CAT GAC CGG CTT CGG CAG AGC CTT CGG TCT GAA AGA AAC	481
Lys Lys Leu His Asp Arg Leu Arg Gln Ser Leu Arg Ser Glu Arg Asn	
145 150 155 160	
ACC ATG ATG AAC GTA GCC AAC GGG CCC CAC CAC CCC AAT CCG CCC CCC	529
Thr Met Met Asn Val Ala Asn Gly Pro His His Pro Asn Pro Pro Pro	
165 170 175	
GAG AAC GTG CAG CTG GTG AAT CAA TAC GTA TCT AAA AAT GTC ATC TCT	577
Glu Asn Val Gln Leu Val Asn Gln Tyr Val Ser Lys Asn Val Ile Ser	
180 185 190	

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FIG. 16B

AGC	GAG	CAT	ATT	GTT	GAG	AGA	GAG	GCG	GAG	AGC	TCT	TTT	TCC	ACC	AGT	625
Ser	Glu	His	Ile	Val	Glu	Arg	Glu	Ala	Glu	Ser	Ser	Phe	Ser	Thr	Ser	
		195					200					205				
CAC	TAC	ACT	TCG	ACA	GCT	CAT	CAT	TCC	ACT	ACT	GTC	ACT	CAG	ACT	CCC	673
His	Tyr	Thr	Ser	Thr	Ala	His	His	Ser	Thr	Thr	Val	Thr	Gln	Thr	Pro	
	210					215					220					
AGT	CAC	AGC	TGG	AGC	AAT	GGA	CAC	ACT	GAA	AGC	ATC	ATT	TCG	GAA	AGC	721
Ser	His	Ser	Trp	Ser	Asn	Gly	His	Thr	Glu	Ser	Ile	Ile	Ser	Glu	Ser	
225					230					235					240	
CAC	TCT	GTC	ATC	GTG	ATG	TCA	TCC	GTA	GAA	AAC	AGT	AGG	CAC	AGC	AGC	769
His	Ser	Val	Ile	Val	Met	Ser	Ser	Val	Glu	Asn	Ser	Arg	His	Ser	Ser	
				245					250					255		
CCG	ACT	GGG	GGC	CCG	AGA	GGA	CGT	CTC	AAT	GGC	TTG	GGA	GGC	CCT	CGT	817
Pro	Thr	Gly	Gly	Pro	Arg	Gly	Arg	Leu	Asn	Gly	Leu	Gly	Gly	Pro	Arg	
			260					265					270			
GAA	TGT	AAC	AGC	TTC	CTC	AGG	CAT	GCC	AGA	GAA	ACC	CCT	GAC	TCC	TAC	865
Glu	Cys	Asn	Ser	Phe	Leu	Arg	His	Ala	Arg	Glu	Thr	Pro	Asp	Ser	Tyr	
		275					280					285				
CGA	GAC	TCT	CCT	CAT	AGT	GAA	AGA	CAT	AAC	CTT	ATA	GCT	GAG	CTA	AGG	913
Arg	Asp	Ser	Pro	His	Ser	Glu	Arg	His	Asn	Leu	Ile	Ala	Glu	Leu	Arg	
	290					295					300					
AGA	AAC	AAG	GCC	CAC	AGA	TCC	AAA	TGC	ATG	CAG	ATC	CAG	CTT	TCC	GCA	961
Arg	Asn	Lys	Ala	His	Arg	Ser	Lys	Cys	Met	Gln	Ile	Gln	Leu	Ser	Ala	
305					310				315						320	
ACT	CAT	CTT	AGA	GCT	TCT	TCC	ATT	CCC	CAT	TGG	GCT	TCA	TTC	TCT	AAG	1009
Thr	His	Leu	Arg	Ala	Ser	Ser	Ile	Pro	His	Trp	Ala	Ser	Phe	Ser	Lys	
				325				330						335		
ACC	CCT	TGG	CCT	TTA	GGA	AGG	TAT	GTA	TCA	GCA	ATG	ACC	ACC	CCG	GCT	1057
Thr	Pro	Trp	Pro	Leu	Gly	Arg	Tyr	Val	Ser	Ala	Met	Thr	Thr	Pro	Ala	
			340					345					350			
CGT	ATG	TCA	CCT	GTA	GAT	TTC	CAC	ACG	CCA	AGC	TCC	CCC	AAG	TCA	CCC	1105
Arg	Met	Ser	Pro	Val	Asp	Phe	His	Thr	Pro	Ser	Ser	Pro	Lys	Ser	Pro	
		355					360					365				
CCT	TCG	GAA	ATG	TCC	CCG	CCC	GTG	TCC	AGC	ACG	ACG	GTC	TCC	ATG	CCC	1153
Pro	Ser	Glu	Met	Ser	Pro	Pro	Val	Ser	Ser	Thr	Thr	Val	Ser	Met	Pro	
		370				375					380					

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FIG. 16C

TCC ATG GCG GTC AGT CCC TTC GTG GAA GAG GAG AGA CCC CTG CTC CTT	1201
Ser Met Ala Val Ser Pro Phe Val Glu Glu Glu Arg Pro Leu Leu Leu	
385 390 395 400	
GTG ACG CCA CCA CGG CTG CGG GAG AAG TAT GAC CAC CAC GCC CAG CAA	1249
Val Thr Pro Pro Arg Leu Arg Glu Lys Tyr Asp His His Ala Gln Gln	
405 410 415	
TTC AAC TCG TTC CAC TGC AAC CCC GCG CAT GAG AGC AAC AGC CTG CCC	1297
Phe Asn Ser Phe His Cys Asn Pro Ala His Glu Ser Asn Ser Leu Pro	
420 425 430	
CCC AGC CCC TTG AGG ATA GTG GAG GAT GAG GAA TAT GAA ACG ACC CAG	1345
Pro Ser Pro Leu Arg Ile Val Glu Asp Glu Glu Tyr Glu Thr Thr Gln	
435 440 445	
GAG TAC GAA CCA GCT CAA GAG CCG GTT AAG AAA CTC ACC AAC AGC AGC	1393
Glu Tyr Glu Pro Ala Gln Glu Pro Val Lys Lys Leu Thr Asn Ser Ser	
450 455 460	
CGG CGG GCC AAA AGA ACC AAG CCC AAT GGT CAC ATT GCC CAC AGG TTG	1441
Arg Arg Ala Lys Arg Thr Lys Pro Asn Gly His Ile Ala His Arg Leu	
465 470 475 480	
GAA ATG GAC AAC AAC ACA GGC GCT GAC AGC AGT AAC TCA GAG AGC GAA	1489
Glu Met Asp Asn Asn Thr Gly Ala Asp Ser Ser Asn Ser Glu Ser Glu	
485 490 495	
ACA GAG GAT GAA AGA GTA GGA GAA GAT ACG CCT TTC CTG GCC ATA CAG	1537
Thr Glu Asp Glu Arg Val Gly Glu Asp Thr Pro Phe Leu Ala Ile Gln	
500 505 510	
AAC CCC CTG GCA GCC AGT CTC GAG GCG GCC CCT GCC TTC CGC CTG GTC	1585
Asn Pro Leu Ala Ala Ser Leu Glu Ala Ala Pro Ala Phe Arg Leu Val	
515 520 525	
GAC AGC AGG ACT AAC CCA ACA GGC GGC TTC TCT CCG CAG GAA GAA TTG	1633
Asp Ser Arg Thr Asn Pro Thr Gly Gly Phe Ser Pro Gln Glu Glu Leu	
530 535 540	
CAG GCC AGG CTC TCC GGT GTA ATC GCT AAC CAA GAC CCT ATC GCT GTC	1681
Gln Ala Arg Leu Ser Gly Val Ile Ala Asn Gln Asp Pro Ile Ala Val	
545 550 555 560	
TAAAACCGAA ATACACCCAT AGATTCACCT GTAAACTTT ATTTTATATA ATAAAGTATT	1741
CCACCTTAAA TTAAACAAAA AAA	1764

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FIG. 17A
(SEQ ID NOS:51-52)

CAT CAA GTG TGG GCG GCG AAA GCC GGG GGC TTG AAG AAG GAC TCG CTG	48
His Gln Val Trp Ala Ala Lys Ala Gly Gly Leu Lys Lys Asp Ser Leu	
1 5 10 15	
CTC ACC GTG CGC CTG GGC GCC TGG GGC CAC CCC GCC TTC CCC TCC TGC	96
Leu Thr Val Arg Leu Gly Ala Trp Gly His Pro Ala Phe Pro Ser Cys	
20 25 30	
GGG CGC CTC AAG GAG GAC AGC AGG TAC ATC TTC TTC ATG GAG CCC GAG	144
Gly Arg Leu Lys Glu Asp Ser Arg Tyr Ile Phe Phe Met Glu Pro Glu	
35 40 45	
GCC AAC AGC AGC GGC GGC CCC GGC CGC CTT CCG AGC CTC CTT CCC CCC	192
Ala Asn Ser Ser Gly Gly Pro Gly Arg Leu Pro Ser Leu Leu Pro Pro	
50 55 60	
TCT CGA GAC GGG CCG GAA CCT CAA GAA GGA GGT CAG CCG GGT GCT GTG	240
Ser Arg Asp Gly Pro Glu Pro Gln Glu Gly Gly Gln Pro Gly Ala Val	
65 70 75 80	
CAA CGG TGC GCC TTG CCT CCC CGC TTG AAA GAG ATG AAG AGT CAG GAG	288
Gln Arg Cys Ala Leu Pro Pro Arg Leu Lys Glu Met Lys Ser Gln Glu	
85 90 95	
TCT GTG GCA GGT TCC AAA CTA GTG CTT CGG TGC GAG ACC AGT TCT GAA	336
Ser Val Ala Gly Ser Lys Leu Val Leu Arg Cys Glu Thr Ser Ser Glu	
100 105 110	
TAC TCC TCT CTC AAG TTC AAG TGG TTC AAG AAT GGG AGT GAA TTA AGC	384
Tyr Ser Ser Leu Lys Phe Lys Trp Phe Lys Asn Gly Ser Glu Leu Ser	
115 120 125	
CGA AAG AAC AAA CCA GAA AAC ATC AAG ATA CAG AAA AGG CCG GGG AAG	432
Arg Lys Asn Lys Pro Glu Asn Ile Lys Ile Gln Lys Arg Pro Gly Lys	
130 135 140	
TCA GAA CTT CGC ATT AGC AAA GCG TCA CTG GCT GAT TCT GGA GAA TAT	480
Ser Glu Leu Arg Ile Ser Lys Ala Ser Leu Ala Asp Ser Gly Glu Tyr	
145 150 155 160	
ATG TGC AAA GTG ATC AGC AAA CTA GGA AAT GAC AGT GCC TCT GCC AAC	528
Met Cys Lys Val Ile Ser Lys Leu Gly Asn Asp Ser Ala Ser Ala Asn	
165 170 175	

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FIG. 17B

ATC ACC ATT GTG GAG TCA AAC GCC ACA TCC ACA TCT ACA GCT GGG ACA	576
Ile Thr Ile Val Glu Ser Asn Ala Thr Ser Thr Ser Thr Ala Gly Thr	
180 185 190	
AGC CAT CTT GTC AAG TGT GCA GAG AAG GAG AAA ACT TTC TGT GTG AAT	624
Ser His Leu Val Lys Cys Ala Glu Lys Glu Lys Thr Phe Cys Val Asn	
195 200 205	
GGA GGC GAG TGC TTC ATG GTG AAA GAC CTT TCA AAT CCC TCA AGA TAC	672
Gly Gly Glu Cys Phe Met Val Lys Asp Leu Ser Asn Pro Ser Arg Tyr	
210 215 220	
TTG TGC AAG TGC CAA CCT GGA TTC ACT GGA GCG AGA TGT ACT GAG AAT	720
Leu Cys Lys Cys Gln Pro Gly Phe Thr Gly Ala Arg Cys Thr Glu Asn	
225 230 235 240	
GTG CCC ATG AAA GTC CAA ACC CAA GAA AAG TGC CCA AAT GAG TTT ACT	768
Val Pro Met Lys Val Gln Thr Gln Glu Lys Cys Pro Asn Glu Phe Thr	
245 250 255	
GGT GAT CGC TGC CAA AAC TAC GTA ATG GCC AGC TTC TAC AGT ACG TCC	816
Gly Asp Arg Cys Gln Asn Tyr Val Met Ala Ser Phe Tyr Ser Thr Ser	
260 265 270	
ACT CCC TTT CTG TCT CTG CCT GAA TAGCGCATCT CAGTCGGTGC CGCTTTCTTG	870
Thr Pro Phe Leu Ser Leu Pro Glu	
275 280	
TTGCCGCATC TCCCCTCAGA TTCCNCCTAG AGCTAGATGC GTTTTACCAG GTCTAACATT	930
GACTGCCTCT GCCTGTCGCA TGAGAACATT AACACAAGCG ATTGTATGAC TTCCTCTGTC	990
CGTGACTAGT GGGCTCTGAG CTA CTCTCGTAG GTGCGTAAGG CTCCAGTGTT TCTGAAATTG	1050
ATCTTGAATT ACTGTGATAC GACATGATAG TCCCTCTCAC CCAGTGCAAT GACAATAAAG	1110
GCCTTGAAAA GTCAAAAAA AAAAAAAAAA	1140

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FIG. 18A
(SEQ ID NOS:53-54)

AGTTTCCCCC CCCAACTTGT CGGAACTCTG GGCTCGCGCG CAGGGCAGGA GCGGAGCGGC	60
GGCGGCTGCC CAGGCGATGC GAGCGCGGGC CGGACGGTAA TCGCCTCTCC CTCCTCGGGC	120
TGCGAGCGCG CCGGACCGAG GCAGCGACAG GAGCGGACCG CGGCGGGAAC CGAGGACTCC	180
CCAGCGGCGC GCCAGCAGGA GCCACCCCGC GAGCGTGCGA CCGGGACGGA GCGCCCGCCA	240
GTCCAGGTG GCCCGGACCG CACGTTGCGT CCCCAGGCTC CCCGCCGGCG ACAGGAGACG	300
CTCCCCCCA CGCCGCGCGC GCCTCGGCC GGTCGCTGGC CCGCCTCCAC TCCGGGGACA	360
AACTTTTCCC GAAGCCGATC CCAGCCCTCG GACCCAACT TGTCGCGCGT CGCCTTCGCC	420
GGGAGCCGTC CGCGCAGAGC GTGCACTTCT CGGGCGAG ATG TCG GAG CGC AGA	473
Met Ser Glu Arg Arg	
1 5	
GAA GGC AAA GGC AAG GGG AAG GGC GGC AAG AAG GAC CGA GGC TCC GGG	521
Glu Gly Lys Gly Lys Gly Lys Gly Gly Lys Lys Asp Arg Gly Ser Gly	
10 15 20	
AAG AAG CCC GTG CCC GCG GCT GGC GGC CCG AGC CCA GCC TTG CCT CCC	569
Lys Lys Pro Val Pro Ala Ala Gly Gly Pro Ser Pro Ala Leu Pro Pro	
25 30 35	
CGC TTG AAA GAG ATG AAG ATG CAG GAG TCT GTG GCA GGT TCC AAA CTA	617
Arg Leu Lys Glu Met Lys Ser Gln Glu Ser Val Ala Gly Ser Lys Leu	
40 45 50	
GTG CTT CGG TGC GAG ACC AGT TCT GAA TAC TCC TCT CTC AAG TTC AAG	665
Val Leu Arg Cys Glu Thr Ser Ser Glu Tyr Ser Ser Leu Lys Phe Lys	
55 60 65	
TGG TTC AAG AAT GGG AGT GAA TTA AGC CGA AAG AAC AAA CCA CAA AAC	713
Trp Phe Lys Asn Gly Ser Glu Leu Ser Arg Lys Asn Lys Pro Gln Asn	
70 75 80 85	
ATC AAG ATA CAG AAA AGG CCG GGG AAG TCA GAA CTT CGC ATT AGC AAA	761
Ile Lys Ile Gln Lys Arg Pro Gly Lys Ser Glu Leu Arg Ile Ser Lys	
90 95 100	
GCG TCA CTG GCT GAT TCT GGA GAA TAT ATG TGC AAA GTG ATC AGC AAA	809
Ala Ser Leu Ala Asp Ser Gly Glu Tyr Met Cys Lys Val Ile Ser Lys	
105 110 115	

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FIG. 18B

CTA GGA AAT GAC AGT GCC TCT GCC AAC ATC ACC ATT GTG GAG TCA AAC Leu Gly Asn Asp Ser Ala Ser Ala Asn Ile Thr Ile Val Glu Ser Asn 120 125 130	857
GAG ATC ACC ACT GGC ATG CCA GCC TCA ACT GAG ACA GCG TAT GTG TCT Glu Ile Thr Thr Gly Met Pro Ala Ser Thr Glu Thr Ala Tyr Val Ser 135 140 145	905
TCA GAG TCT CCC ATT AGA ATA TCA GTA TCA ACA GAA GGA ACA AAT ACT Ser Glu Ser Pro Ile Arg Ile Ser Val Ser Thr Glu Gly Thr Asn Thr 150 155 160 165	953
TCT TCA TCC ACA TCC ACA TCT ACA GCT GGG ACA AGC CAT CTT GTC AAG Ser Ser Ser Thr Ser Thr Ser Thr Ala Gly Thr Ser His Leu Val Lys 170 175 180	1001
TGT GCA GAG AAG GAG AAA ACT TTC TGT GTG AAT GGA GGC GAG TGC TTC Cys Ala Glu Lys Glu Lys Thr Phe Cys Val Asn Gly Gly Glu Cys Phe 185 190 195	1049
ATG GTG AAA GAC CTT TCA AAT CCC TCA AGA TAC TTG TGC AAG TGC CCA Met Val Lys Asp Leu Ser Asn Pro Ser Arg Tyr Leu Cys Lys Cys Pro 200 205 210	1097
AAT GAG TTT ACT GGT GAT CGC TGC CAA AAC TAC GTA ATG GCC AGC TTC Asn Glu Phe Thr Gly Asp Arg Cys Gln Asn Tyr Val Met Ala Ser Phe 215 220 225	1145
TAC AGT ACG TCC ACT CCC TTT CTG TCT CTG CCT GAA TAGGCGCATG Tyr Ser Thr Ser Thr Pro Phe Leu Ser Leu Pro Glu 230 235 240	1191
CTCAGTCGGT GCCGCTTTCT TGTGCGGCA TCTCCCTCA GATTCAACCT AGAGCTAGAT	1251
GCGTTTTACC AGGTCTAACA TTGACTGCCT CTGCCTGTCG CATGAGAACA TTAACACAAG	1311
CGATTGTATG ACTTCCTCTG TCCGTGACTA GTGGGCTCTG AGCTACTCGT AGGTGCGTAA	1371
GGCTCCAGTG TTTCTGAAAT TGATCTTGAA TTAAGTGTGAT ACGACATGAT AGTCCCTCTC	1431
ACCCAGTGCA ATGACAATAA AGGCCTTGAA AAGTCTCACT TTTATTGAGA AAATAAAAAT	1491
CGTTCACGG GACAGTCCCT CTCTTTATA AAATGACCCT ATCCTTGAAA AGGAGGTGTG	1551
TTAAGTTGTA ACCAGTACAC ACTTGAAATG ATGGTAAGTT CGCTTCGGTT CAGAATGTGT	1611
TCTTTCTGAC AAATAAACAG AATAAAAAAA AAAAAAAA A	1652

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled THERAPEUTIC METHODS COMPRISING USE OF A NEUREGULIN, the specification of which

- ☐ is attached hereto.
☒ was filed on May 5, 2000 as Application Serial No. 09/530,884
and was amended on _____.
☒ was described and claimed in PCT International Application No. PCT/US98/21349
filed on _____ and as amended under PCT Article 19 on _____.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information I know to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56(a).

FOREIGN PRIORITY RIGHTS: I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

Country	Serial Number	Filing Date	Priority Claimed?
PCT	PCT/US98/21349	08 October 1998	Yes

PROVISIONAL PRIORITY RIGHTS: I hereby claim priority benefits under Title 35, United States Code, §119(e) and §120 of any United States provisional patent application(s) listed below filed by an inventor or inventors on the same subject matter as the present application and having a filing date before that of the application(s) of which priority is claimed:

Serial Number	Filing Date	Status
60/062,109	14 October 1997	Abandoned

NON-PROVISIONAL PRIORITY RIGHTS: I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by

COMBINED DECLARATION AND POWER OF ATTORNEY

the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose all information I know to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Serial Number	Filing Date	Status

I hereby appoint the following attorneys and/or agents to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: Paul T. Clark, Reg. No. 30,162, Karen L. Elbing, Ph.D. Reg. No. 35,238, Kristina Bieker-Brady, Ph.D. Reg. No. 39,109, Susan M. Michaud, Ph.D. Reg. No. 42,885, Mary Rose Scozzafava, Ph.D., Reg. No. 36,268, James D. DeCamp, Ph.D., Reg. No. 43,580.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

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Signature: <i>Mark Marchionni</i> MA			Date: 2/5/00